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COMPARISON BETWEEN TORPEDO BOAT AND MERCHANT MARINE ENGINES.

By Dr. Alfred Gradenwitz.

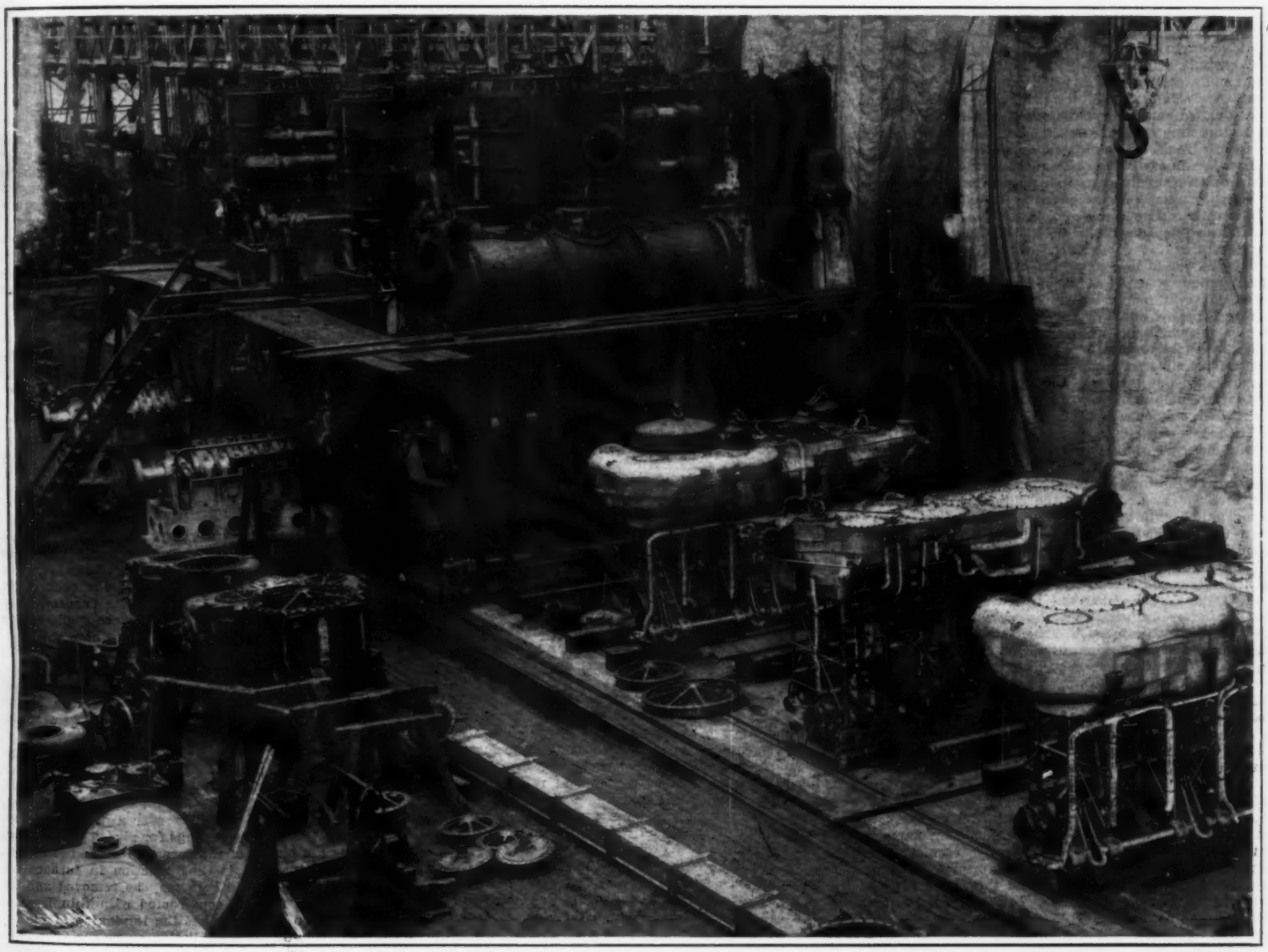
A short time ago it so happened that in the workshops of the Germania shipyards at Kiel-Gaarden, two steam-engine sets of the same output were erected side by side, one of which was intended for a torpedo boat, the other for a merchant steamship. The accompanying photograph affords an excellent opportunity of comparing the characteristic features of the two types of engines, while the main data of each are recorded in the following table. Of the three torpedo-boat engines in the foreground of the photograph, each of 3,000 horse-power, two are to be installed in a torpedo boat of 426 tons displacement, giving it a maximum calculative speed of 30 knots per hour. The two slow-speed engines towering in the background are also of 3,000 normal horse-power each. They will be used in a 13,500-ton freight steamer of 13½ knots speed.

	Merchant Vessel.	Torpedo Boat.
Horse-power of each engine	3,000	3,000
Cylinder diam. in inches	24, 35, 51, 75	1.6, 32.4 47.6
Stroke in inches	54.8	20
Number of revolutions per minute	80	350
Speed of piston in feet	12.05	19.25
Steam pressure in pounds per sq. in.	220	250
Diameter of shaft in inches	15.04	7.04
Total weight in pounds	462,000	36,000
Weight per I. H. P. in pounds	154	11.9
Height in feet	23.13	8.68
Base dimensions in feet	13.5 x 31	5.3 x 13.2
Strain on shafts, in pounds per sq. in.	2,980	6,950
Material of shafts	Siemens-Martin steel	Special steel.

The high number of revolutions in the torpedo engine is especially striking as compared with that of the mercantile ship engine, while other features characteristic of the former are the smaller stroke, high piston speed, and above all the exceedingly small weight and dimensions. The strain on the shaft is obviously very much greater in the torpedo engine than in the other type of the same output.

The question now naturally arises why it is not feasible to supply freight steamers with engines which, while not as light as those of the torpedo boat, would at least approach the present mean weight of the two types shown, or say, 60 to 75 pounds per horse-power, for the lighter the engine is made the larger is the useful weight which the vessel can carry, and correspondingly greater the amount it can earn through its freight charges. This is undoubtedly true, and it points the way along which marine architecture has so far advanced and will continue to advance in the future. Meanwhile, so great a step forward is not possible for reasons of practical utility. The small torpedo boats are high-speed craft, and they must accomplish by means of higher rates of revolution what they are unable to perform because of small propeller surface. The stroke is only 1.64 foot, while that of the merchant-vessel engine driving the larger propeller is nearly three times this figure. As is well known, the movement of reciprocating engines sets the entire body of the vessel to vibrating, the intensity of the oscillations being proportional to the speed of revolution. Though the vibration can be decreased by compensatory methods, it is still impossible to obviate it altogether. These vibrations are injurious to a ship, and decrease its length of life at sea. This is of importance in the case of a merchant vessel, which is a more profitable investment the longer it is in service. This is a rule which, in the case of war vessels, while not negligible, is by no means decisive. With these it is primarily a question of the performance of a specific purpose, for instance, in a torpedo boat, the development of the highest possible speed. For this reason, the best available resources of the times are employed; all other questions and considerations are subservient to these. This is also true of the original cost of the engines. This is so much greater for the small engines of the torpedo boats, than for the larger ones of the merchant vessel, that the use of such expensive machinery for the latter is precluded by the commercial conditions of to-day.

What was said of the difference in the weights of the two compared engines is correspondingly true of the space requirements. One engine of the merchant vessel requires a space (base area by height) of 9,536,825 cubic feet, the torpedo engine 594,170 cubic feet; in other words, that of the first is sixteen times as great as that of the latter. In the case of the merchant vessel, the smaller the engine space, the greater is the room for cargo. The engines extend from the bottom of the ship to the upper deck. That large slow-moving engines can also be built of less height is demon-



TWO SETS OF ENGINES EACH OF 3,000 HORSE-POWER. THE LARGER ENGINES ARE TO BE INSTALLED IN A MERCHANT STEAMER, THE SMALLER IN A TORPEDO BOAT.

strated in the case of war vessels, where the engines are located under the armored deck. This arrangement shows that the ventilation of the engine room is also possible under these conditions.

For merchant vessels the mentioned disadvantages would be decreased if it should be possible to better the fuel consumption of turbine engines, so that these would become available for slow vessels. Turbine engines produce no vibrations of the ship's hull, and they have smaller space requirements than reciprocating engines of equal output. In that case the engines of a merchant vessel and of a torpedo boat, placed alongside one another, would present no such picture as in the present instance.

[Continued from SUPPLEMENT No. 1570, page 25160.]

LIQUID FUEL FOR NAVAL AND MARINE USES.*

By Rear-Admiral GEORGE MELVILLE, Former Chief Engineer, United States Navy.

Modification in Boiler Design Required by Liquid Fuel.

BOILER VOLUME.—Consideration of the mechanics of combustion as applied to liquid fuel appears to show that, for the efficient burning of the latter, it is necessary to provide boilers of greater volume than are now constructed for a given horse-power.

Complete combustion requires that for every atom of carbon, and for every two atoms of hydrogen there shall be at least one atom of oxygen brought in close proximity and then and there subjected to a temperature sufficient for ignition. In other words there must be a thorough mixture and then ignition. It is doubtful if a mere mechanical mixture, however complete, could ever be perfect enough to bring about the desired result. This is well illustrated by contrasting the smoky combustion of black gunpowder, where we have a mechanical mixture, with the combustion of the so-called smokeless powders, in which the mixture is so thorough and minute that similar proportions of oxygen, carbon, and hydrogen occur in each molecule.

In all ordinary cases of combustion, however, where we draw our supply of oxygen from the atmosphere, it is only by virtue of the property of diffusion that a sufficiently intimate mixture is attained. As to the real nature of diffusion, it is known that at ordinary temperatures the particles of oxygen in the air are moving about in every conceivable direction at velocities averaging over 1,600 feet per second. Any one atom, however, moves only an inappreciable distance before being arrested by collision with another atom. So that although the average velocity of the atoms is probably equal to that of a rifle ball, it still takes an appreciable time for a particle to travel even a moderate distance. It is this time element that constitutes the great stumbling block when the attempt is made to burn a large amount of combustible in a small space.

The reason why intense combustion is easily attained with a charcoal fire is that the fuel is solid at the temperature of ignition. Being solid it can present a large surface for the oxygen to act upon, and an atom cannot break away and go up the chimney without first being united with at least one atom of oxygen.

In the combustion of hydrocarbons, on the other hand, we have the following conditions: The fuel is already on its way to the chimney before it is even partially burned. The first effect of the heat is to dissociate the carbon from the hydrogen. Whether or not the latter unites with the oxygen does not affect the soot or smoke question, since the constituents and also the products of combustion of hydrogen are alike transparent colorless gases. But in any case, the carbon, left alone in the form of an impalpable dust, is much less favorably circumstanced than that in a charcoal fire. If it were attached to a hot coal, as in the charcoal fire, so as to be capable of receiving a blast of air, its combustion would be easily accomplished. But instead of this, it is carried along by the current of gases, and unless it is given plenty of time before being cooled it will be left alone as a particle of soot.

An examination of the nature of flaming leads to similar conclusions. The luminous part of a flame is caused by the white-hot particles of carbon. These particles have been robbed of the hydrogen with which they were formerly associated, and they have not yet met the oxygen necessary for complete combustion. This process of finding, or of being found by, the oxygen requires time, and if perchance the temperature falls below that of ignition before the process is completed, the carbon will be deposited as soot or else go on up the stack as smoke along with the excess of oxygen with which it should have been united. Thus an unmistakable symbol of the conditions that are necessary in order to burn a large amount of combustible in a small space is a short flame.

The circumstances which conduce to shortness of flame are:

1. Pure carbon fuel, because the fuel cannot leave the grate or furnace until it is burned to CO at least. In any case it cannot deposit soot, since CO when cooled is a transparent gas.

2. Intimate initial mixture of oxygen with the fuel, since the more intimate the mechanical mixture the less time will it take the gases by the process of diffusion to become perfectly mixed.

3. Initial heating of the air, since the rate of diffusion decreases with temperature.

4. Large surface of fuel presented for impact of the oxygen.

The desirability of supplying a combustion chamber whose volume is at least equal to the volume of the flames seems obvious. In this connection the fact should not be overlooked that a slight increase in the volume of the combustion space acts in two ways to improve the quality of the combustion. One way—that having to do with the greater time permitted for diffusion—has already been touched upon; but apart from that there are influences at work in consequence of which an increase in the volume of the combustion space actually diminishes the volume of the flames. This is because the temperature of the larger space is higher, and the higher temperature hastens the process of diffusion.

During the process of diffusion heat is being liberated at all points throughout the combustion space. Hence all parts of the space are being traversed by heat rays emanating from every other part of the combustion chamber. It is readily seen that the temperature within this space must under these conditions increase with the volume to an extent limited only by the transparency to radiant heat, and by the temperature of dissociation at which, necessarily, heat ceases to be liberated. Since the transparency of the combustion space is diminished by the presence of solid carbon (for whether black or incandescent it is in any case opaque), it follows that the increase of temperature with a given increase of volume will be less in space filled with luminous flame than in one filled with burning hydrogen or CO.

This question of the proper size of the combustion space is further complicated by the presence and condition of the solid walls of the furnace, whether, for instance, they are themselves incandescent or merely black absorbers of heat. There seems no reasonable doubt, however, that incandescent walls will hasten diffusion and hence shorten flame.

Where it is possible for the diffusion to be completed before combustion begins as in the Bunsen gas burner the difficulties naturally disappear and there is readily attained a very short flame which, moreover, is incapable of depositing soot even on a cold object.

In the case of a liquid fuel which is incapable of vaporization, the diffusion and ignition must occur simultaneously. With such a fuel there is bound to be considerable flaming. Another difficulty, and one from which all solid fuels are free, arises with this sort of fuel from the action of capillarity or surface tension. Thus, no matter how finely the liquid is pulverized, each tiny drop assumes a spherical shape and so presents the least possible surface for the impact of oxygen atoms.

From what has been said it seems clear that a liquid fuel such as crude petroleum requires an ample combustion space, more indeed than does almost any other sort of combustible material.

As to the difficulty arising from the tendency of the gases to follow the path of least resistance and to flow, for instance, with too great velocity at the center of the space and too little at the sides, that can always be checked by means of retarders placed so as to equalize the velocity over the cross section of the current. The difficulty, therefore, reduces itself to the mere trouble of finding out where to place the retarders, and this is obviously a question to be settled by experiment. What is true in this matter of the combustion space is also largely true of the tube space. The process of diffusion, so important to combustion, continues after the combustion is complete, and must have a good deal to do with the rate at which heat is abstracted from the gases by the heating surfaces. As affecting the necessary amount of draft pressure, a tube space short in the direction of flow of the gases and of large cross-sectional area is better than one of small area and long in the direction of flow; but on account of the lesser velocity of flow through the short space the gases within it will be less thoroughly mixed by eddying, and the importance of arranging the heating surfaces so as to permeate all parts of the space will be increased.

A study of the liquid fuel problem from the standpoint of the practical or mechanical rather than the theoretical or chemical feature of combustion would therefore show that when an assured and reasonably cheap supply of such fuel can be obtained, and when steam generators are designed for burning oil exclusively, it will be essential for the efficient and forced burning of such fuel to provide boilers of greater volume than now constructed for designated horse-powers.

FURNACE CONSTRUCTION.—Where there is no desire to force the combustion of liquid fuel, the simple cylindrical furnace of the Scotch boiler has been found fairly suitable, particularly if an extension to the front of the furnace is made, so that complete combustion can be effected before the gases pass through the tube.

With the water-tube boiler the problem becomes a more complicated one, at least so far as economy is concerned. Where the gases pass through the tubes, as in the case of the Scotch boiler, the resulting friction is sufficiently great to cause the gases to be abstracted of sufficient heat to produce a comparatively low temperature at the base of the stack. Where the gases pass around the tubes, as in the case of a water-tube boiler, there is but little impeding of the flow, and as a result stack temperatures are comparatively high. When burning oil in bent-tube types of boilers combustion is often only completed near the top rather than near the base of the stack or funnel.

The question of baffling of gases in a water-tube boiler is one of supreme importance, for not only does it concern the economic efficiency but the endurance of the boiler itself. The straight tube water-tube boiler ought, however, to possess special advantage for the burning of oil by reason of the fact that it is possible to secure a combustion chamber of considerable volume, so that complete combustion of the fuel can be effected.

Scotch marine boilers, on account of their contracted volume of furnace, produce difficulties in the introduction of oil, and by reason of the small cubical space permissible for combustion purposes it is requisite that careful study should be given to the disposition of the brick work in, or surrounding a furnace. It is, of course, quite possible to spray the oil at once into the metallic fire box or furnace of the Scotch boiler, the flame impinging on the cold surfaces of the steel plates; but although this is often done, yet it cannot in any case be recommended as good practice. For successful combustion of oil it is requisite that the issuing oil spray should not too early in its progress of combustion strike the chilled or comparatively cold surfaces of the metal work. Carefully designed oil-burning furnaces require that the furnaces should be either partially or wholly bricked around.

The fact of heated brickwork is in itself a very great advantage in aiding combustion, and of still greater use in insuring perfect continuity of the heat supply, especially when burners tend to act in gusts, as they often do under improper action of the pumps, or where there is dirt or water in the oil supply.

The brickwork surrounding the interior of the Scotch furnace ought not to constitute a serious loss in thermal effect, because the brick itself early becomes incandescent and transmits a large portion of its heat directly to the metal in a steady and continuous flow.

Various forms of brick construction may be used in the cylindrical furnace. For example, the furnace may be lined throughout and the brick work also extended well into the combustion chamber in order to protect the back connection from the direct impact of flame. The burner may be fitted in the middle of the fire door, spraying directly into the furnace and utilizing the whole volume of the latter for combustion. Again, the combustion chamber may be bricked, the bridge wall left in place, the standard forms of grate bars left intact, and the top of the bars paved with fire brick, having interstices between the bricks. The furnace, however, should not be lined, in order to retain the maximum volume. By this plan, the oil burning installation can be readily removed and the furnace prepared for the use of coal. Again, the furnace may be fitted with a small wagon top arch at the usual location of the bridge wall, and, behind the arch, space be left for a combustion chamber. The latter and the furnace should be lined with fire-brick, excepting over the arch in order to avoid checking the gas flow there. This plan insures an intimate mixture of flame and gases but shortens the active length of the furnace. The latter disadvantage may be met by extending the front of the furnace by a projecting casting, suitably lined. Other modifications in furnace design are essential in the use of mechanical burners, when compressed air or steam is not employed and the air for combustion requires to be fed in heated, rotating currents.

Water-tube boilers have usually somewhat greater volume in their fire boxes than the furnaces of the Scotch boilers, consequently the opportunities are greater to arrange the brick work to suit the peculiar conditions required by oil fuel. With most of these boilers it is quite customary to put the burners into the fire doors or the spaces which would have been occupied by fire doors. As a matter of fact, it would often be better to put the burner at the back of the boiler and fire toward the front of the furnace, as by this means the larger end of the furnace would receive the gases of combustion at the point where the greatest expansion was taking place.

Owing to the fact that all the gages, fittings and connections are on the front of the boiler, it becomes an advantage to have the burner also, therefore, located on the front rather than on the back, where it would be practically inaccessible.

As with Scotch boilers, various modifications of furnace construction are possible or desirable. The grate bars may be removed and the burners fitted in the front to spray into the entire volume of the furnace. Again, the burners may spray over a paved grate, set with fire brick having openings for air. The advantage of this is the fitness of the furnace for the use of coal, also its disadvantage is the reduction in furnace volume. Again, the grate bars may be removed and the bottom of the furnace constructed of a thin layer of brick work, so arranged that the impinging of the hot gases and the effects of radiation cause the floor to be heated to a considerable temperature. The air entering for combustion and passing under this floor is quickly heated, thus increasing the efficiency of the furnace. Many other modifications are possible. The furnace may be fitted with a flat arch or a series of wagon top arches, with or without a combustion chamber behind the arch. A hot-air floor may be added, the front of the furnace extended as noted for Scotch boilers, and, if necessary, special spiralized air-heating devices fitted.

Equipment for Oil Fuel.

STRAINERS.—The majority of the crude oils having been obtained from wells driven into the earth, of necessity carry in the body of the oil, more or less intimately mixed, certain small proportions of water, as well as more or less sand or grit. The heavier and more viscous the oil, the greater the tendency there is to hold in suspension these deleterious substances.

In general it can be assumed that no crude oil is perfectly clean. Therefore in the installation of any oil-burning plant special provision should be made for straining out all sand and foreign matter. Arrangements should always be provided for catching the water as it slowly settles to the bottom of the tanks or bunkers.

* Paper presented before the Congress of the Permanent International Association of Navigation Congresses.

The effect of sand in oil increases the wear on the small annular nozzles of the oil burner, or, when using burners provided with specially small orifices, these openings may become altogether clogged.

The gage used for oil strainers should not be too open, and should be formed of brass wires or probably a width of mesh work equal to about half the width of oil orifice in the burner.

In the placing of these strainers it is not unusual to find a strainer placed on the oil pipe on each side of the pump, thus insuring that no grit gets into the pump, and that any particles of old packing or other material from the pump can not go to the burner through the last filter. A still more desirable plan is to have two strainers between the pump and the burners, so that when one filter is being opened the current of oil can be transferred by means of a by-pass valve through the other filter.

Separation of Water.

There is no practicable device that will directly separate the water from the oil. This separation can only be satisfactorily effected by allowing the water to settle to the bottom of the tanks by gravity. It therefore follows that if the suction to the oil pumps is placed in the bottom of the tanks, water will be often drawn when only oil is desired. A thread of water blown into the oil burner effectually extinguishes the flame in the furnace, and if the oil does not soon follow the water, there may be difficulty in relighting without introducing an outside flame. In order to insure a supply of oil from the tank without an admixture of water, devices have been adopted whereby the oil suction pipe is caused to swing up or down in the oil bunker to a level at which it is known that pure oil can always be obtained.

In a construction used in English tank strainers, the movable oil suction pipe is carried by a float. The suction tip is thus always maintained at a point within a few inches of the top of the oil. The tip is also surrounded by a steam heating coil, the object of which is to slightly heat the oil in proximity to the inlet, thus increasing the fluidity of the oil, so that even in cold weather the oil may be readily pumped.

At the bottom of each bunker there should always be provided a water cock or blow-off for the purpose of blowing off any water which may be found to have settled in the tank or compartment.

Certain crude oils at the ordinary temperature of the atmosphere are of great viscosity, which viscosity increases as the temperature gets lower. At 30 to 40 deg. F., which is not an unusual outdoor temperature, the fluidity of the oil is so light that it is almost impossible to pump the oil or to force it to the burner. It is therefore necessary where fuel oil is to be used in regions which are subjected to severe winter temperatures that there should be means for heating the oil so that it may more readily flow to the pumps. The usual manner of accomplishing this is not to attempt to heat the whole tank or bunker of oil, but simply to heat the oil immediately surrounding the suction pipe to the pumps. This can be easily accomplished by placing a coil of a few turns of steam pipe about the suction pipe.

In all pipes intended for the transmission of crude oil it is desirable that connections should be made to them so that steam can be turned into the pipes after shutting off the oil. These pipes can be thus cleaned by the heat and the force of the blowing steam, and any deposited asphalts, paraffins, or condensed hydrocarbons can be cleared out before the pipes become choked so as to impair their efficiency.

The heating of the oil should be always recommended as an aid to secure better operation of pumps and burners, but this heating should never be carried to such a degree of temperature as will cause decomposition of the hydrocarbons of the oil. The degree of temperature at which such decomposition is likely to occur has been ascertained for the oils of each region.

Oil Pressure Regulators.—With most burners it is desirable that a uniform pressure should be maintained on the oil circuit to the burner. If it were possible to keep the pumps automatically and perfectly regulated, a uniform pressure could be secured.

A reliable plan is to provide the oil chamber of the pump with what would correspond to an air chamber on the water pump, or to provide a separate tank or chamber in which a constant air pressure is maintained on top of the oil by additional means.

In all oil installations it is very important that the control of the oil pump and of the steam to the burner or of the compressed air, where air is used, should be so arranged that in case the delivery of any one of the fluids is reduced, or interrupted, a corresponding reduction or shutting off should be effected in the supply of the other elements.

It is especially important that oil should in no case continue to be forced or pumped to the burners when the steam or air required for spraying is shut off, as in such an event the unsprayed oil is liable to flood in upon the hot brickwork and a furnace explosion is sooner or later likely to occur. The underwriters' regulations in many cases specifically require that in the event of the stoppage of the oil flow to the burner all the other functions shall be caused automatically to cease.

Tank Ventilation.—In the storage of fuel oil on shipboard, it is of the highest importance, not only that the most careful attention should be devoted to the method and quality of riveting, to secure oil tightness of bunkers and double bottoms, but that great care should be exercised in the design of the oil tank ventilation devices. It is well known that all crude oil generates more or less vapor of an explosive nature, and this vapor being heavier than the air, rests upon the top of the oil in tanks or bunkers. This vapor can be removed by natural or artificial means, but as the formation of the vapor from a tank of oil proceeds rather slowly, it is usually found that a system of natural ventilation can be devised so that sufficient of the vapor can easily be removed.

All ventilating heads or cowls should proceed as direct as possible to weather decks, but should be located not near the smoke stack. In all circumstances the oil ventilating cowls should be fitted with fine wire gauze soldered into the cowl opening. This wire gauze permits easy exit of vapor, while preventing any back flash into the vapor pipe from a stray spark from the main funnel or a light from a careless smoker on deck.

These oil ventilation cowls from their very exposed position are often caught by the rush of heavy shipped seas, and salt water is likely to pour down into them. Hence it is desirable to goose-neck these cowl pipes as is often done on board torpedo boat ventilator pipes, or to design a cowl pipe with a light ball float which will close under the presence of water in the manner of a check valve.

Air Compressors.—In marine work it is generally recognized that compressed air should be used as a spraying medium rather than steam, in order to prevent the loss of fresh water which is entailed by the use of steam as a spraying medium. In the types of burners generally used the amount of compressed air required is considerable, and the sizes of air compressors installed are such as to constitute quite an addition to the mechanical apparatus placed in the engine room.

The result of these considerations is that for marine purposes when vessels are intended for short voyages it will probably be found more satisfactory to employ steam and to buy water at the ports of call rather than to use the large and cumbersome air compressors required.

Certain classes of burners have been operated with air at much lower pressures by use of blowers rather than air compressors. For marine purposes the results are somewhat more satisfactory, probably, than with the compressors, but still the blowers occupy considerable room in the engine or boiler rooms, and there is somewhat of a question whether as satisfactory a combustion can be obtained with burners under low pressure as with burners operating under high-pressure air.

The Availability in General of Oil as Fuel.

With regard to the general availability of liquid fuel, the following factors should be considered:

Relative Evaporative Efficiency.—The relative evaporative efficiency of oil and coal as a fuel, as determined by this extended series of comparative experiments, is practically in the proportion of 15 to 10. The actual superiority of oil will be considerably greater, for in the coal experiments unusual skill was exercised in the management of the fires. Lump coal of superior quality was used; and as the tests with coal were of comparatively short duration, the resulting loss from cleaning fires was much less than would occur in actual service. The oil experiments, however, were carried on under conditions that more closely approximated those that could be secured on board the sea-going vessels. The actual evaporative efficiency of a pound of oil as compared with a pound of coal will therefore be in the ratio of 17 to 10, and these figures can be regarded as substantially correct.

It will be found, practically that the thermal efficiency of a pound of oil is the same whether the oil be crude or refined. While the crude oils contain sulphur and other chemical elements that are low in thermal efficiency, they contain substances that are particularly rich in hydrogen. In the process of distillation not only the sulphur, but the rich hydrocarbons are lost, and it can thus be expected that in the commercial burning of oil as fuel, the evaporative efficiency of the same weight of oil fuel from every field or district will be practically the same.

From the standpoint of volume, therefore, it will be found that the highest evaporative results ought to be secured from the heaviest oil. As oil is sold by the gallon, and therefore by volume, the California product, from the fuel standpoint, ought thus to have an advantage over the yield from other fields. For some time, however, it can be expected that extra trouble and expense will be incurred in efficiently and uniformly burning heavy oils. There is not likely to be any actual advantage, therefore, from the use of heavy oils as viewed from the standpoint of weight of fuel.

Relative Cost.—The relative value of coal and oil as fuel is influenced so much by the conditions of each case that no general rule, covering all conditions, can be laid down.

Probably no more striking way of actually showing the relative commercial value of coal and oil as a fuel, could be presented than by stating that the Atchison, Topeka & Sante Fe Railroad Company made the following comparative tests, of the cost per train mile, of coal costing $6.65 per ton and petroleum costing $1.33 per barrel.

Twenty-five passenger and freight engines on a thirty-day run, used 2,077 tons of oil and traveled 87,063 miles, or 41.9 miles per ton, or 3,500 miles per month per engine. Oil at $1.33 per barrel would, at this figure, cost 14.4 cents per mile. Twenty-five passenger and freight engines (same days, same track, and same condition) burning coal, cost 23.2 cents per mile. The oil was 15 Baume, about the same as the Kern River oil, which is 14 to 17 Baume; this showed a saving for oil of 38 per cent, and the experiment was tried with coal at $6.65 per ton.

In this extended and practical test the cost of the oil per barrel was one-fifth of the cost of the coal per ton, while the resulting gain for oil was 38 per cent. Stated in another form, the value of the two fuels would be the same when the price of the coal in tons was three and one-half times the price of the oil in the barrels.

General Requirements for Efficient Combustion.

Admission of Air.—Where oil is used as a fuel, there should be determined, by practical experiment for various conditions, the size of openings in ash pits requisite for admitting air essential for completing combustion. In the use of Liquid Fuel there will always be a tendency to admit too much air, and this should be checked by the installation of a series of dampers whose opening could be closely regulated.

Where coal is used on the grates, such fuel remains for an appreciable interval of time on the bars, and thus checks the passage of air from the ash pit. The bed of incandescent fuel thus limits the amount of air that will reach the combustion chamber.

Where oil is used as a fuel there is no corresponding interference with the draft from the ash pit. On the contrary, the heating of the air increases the velocity of the current. The reduction in the time available for the diffusion of the particles of oil with the air undoubtedly more than offsets the advantage due to the rapidity with which the subdivision of the oil particles is effected.

One of the principal problems in successful oil burning will thus be, to impede the flow of the gases so that complete diffusion of the particles of oil will take place in the combustion chamber and amid the tubes. Such devices as bridge walls, arches, deflectors, baffles, and other forms of furnace construction undoubtedly check in part the flow of the gases. The difficulty of impeding the flow of the gases will, therefore, prevent the economical installation of oil burners in special forms of bent water-tube boilers. It is probable that oil fuel installations in marine water-tube boilers will be limited to those types which admit of extensive baffling.

Hygrometric Conditions.—The oil fuel experiments had been conducted but a short period before it was observable that the hygrometric state of the atmosphere had an important influence upon both evaporative efficiency and evaporative capacity.

The decrease of efficiency due to humidity can be ascribed to two causes:

1. To the displacement of a certain amount of oxygen in a given volume of air by the moisture of the atmosphere, thus requiring an excess in volume of air for completing combustion, with consequent loss of heat in the stack.

2. To the decreased rapidity of diffusion of the combustible gases with the oxygen due to the presence of the inert moisture.

Thermal Effect of Steam Atomizing.—There is a widespread misconception regarding the part that the steam which is used for atomizing purposes plays in effecting combustion. It is supposed by many, that after atomizing the oil, the steam is decomposed and that the hydrogen and carbon are again united, thus producing heat and adding to the heat value of the fuel. While it may be true that the presence of steam may change the character and sequence of the chemical reaction and result in the production of a higher temperature at some part of the flame, such an advantage will be offset by lower temperatures elsewhere between the grate and the base of the stack. All steam that enters the furnace will, if combustion is complete, pass up the stack as steam, also carrying with it a certain quantity of waste heat. The amount of this waste heat will depend upon the amount of steam and its temperature at entrance of the furnace. The quantity of available heat, measured in thermal units, is undoubtedly diminished by the introduction of steam. In an efficient boiler it is quantity of heat rather than intensity that is wanted. For many manufacturing purposes intensity of heat may be of primary importance, but in a marine steam generator a local intense heat is objectionable on other grounds than those of economy, viz., its liability to cause leaky tubes and seams from the unequal expansion of heating surfaces.

Character of Installation.—When oil is used as a fuel, it is essential to have an installation of the best workmanship throughout. The searching and destructive power of petroleum vapors with the resultant dangers from careless handling, cheaply built tanks, and ill fitted piping make a liberal expenditure in first cost a wise economy in the end. Such a plant also cannot be operated successfully for any extended period by cheap labor. For sustained efficiency, skilled attendance is essential.

Supply of Crude Petroleum.—While the successful and economical use of oil as fuel seems unquestionable, its extended employment as such is, at present, doubtful, owing to limited supply.

When it is considered that crude petroleum is extensively used in the arts and sciences, as well as for lubricating and illuminating purposes, it is probable that less than one half of the world's production of crude petroleum is available for fuel. Regarding 3 to 3½ barrels of oil as the equivalent of 1 ton of coal, it will be observed that less than three per cent of the world's production of fuel can possibly be secured from the use of crude petroleum.

Independent of the question of cost, the use of oil as fuel for either manufacturing, maritime, or naval

purposes must therefore for a time be considered as limited, by reason of the shortness of supply.

While Russia produces about 44 per cent of the world's output of petroleum, her oil fields are not located advantageously for use, either by her navy, or by foreign commerce. From a military standpoint, the United States, which produces 48 per cent of the world's output, is the only naval power which could hope to utilize to any great extent this fuel for naval and maritime purposes. This is because the Texas and California oil fields are within comparatively short distances of great maritime ports and possible scenes of naval operations.

A recent estimate, prepared by the United States Geological Survey, gives the world's annual production of coal as about 941,000,000 tons of 2,000 pounds, of which amount the United States supplies 32 per cent.

The following table gives the production, approximately, of crude petroleum in all of the known countries, together with the percentage of each for 1901 and 1902, in terms of United States barrels, at 42 gallons per barrel of 231 cubic inches per gallon. A small estimated quantity has been placed under the head of "all other countries." This quantity includes a primitive production in several of the South American States, Algeria in Africa, Persia, the Philippines, and China, from which no returns could be secured.

The total increase in 1902 amounted to almost 12 per cent as compared with 1901, to almost 25 per cent as compared with 1900. The most conspicuous items in the list are the increase in the production of the United States and the decrease in the production of Russia, the United States, for the first time in five years, surpassing Russia in production by 8,226,871 barrels. The United States and Russia produced, in 1902, 91.44 per cent of the total output as compared with 93.22 per cent in 1901 and with 94.11 per cent in 1900. Of the remaining 8.56 per cent Sumatra, Java, Borneo, Galicia, and Roumania, which furnished only 4.65 per cent in 1901, furnished 6.52 per cent in 1902, leaving 2.04 per cent of the total as the output of all the other producing countries.

WORLD'S PRODUCTION OF CRUDE PETROLEUM IN 1901 AND 1902.*

Country.	1901.		1902.	
	Quantity in barrels of 42 U. S. gallons.	Per cent of total.	Quantity in barrels of 42 U. S. gallons.	Per cent of total.
United States	69,389,194	41.84	88,766,916	47.94
Canada	572,800	0.35	520,000	.28
Peru	72,261	0.04	60,000	.03
Russia	85,168,556	51.38	80,540,045	43 50
Galicia	3,251,544	1.96	4,142,160	2.24
Sumatra, Java, Borneo	3,038,700	1.84	5,860,000	3.17
Roumania	1,406,160	.85	2,059,930	1 11
India	1,430,716	.86	1,617,363	.87
Japan	1,100,000	.67	1,193,000	.64
Germany	313,630	.19	353,675	.20
Italy	10,100	.02	12,000	.02
All other countries	20,000		26,000	
Total	165,773,863	100.00	185,151,089	100.00

As to the supply of crude petroleum available in the United States for fuel purposes, Prof. Arthur L. Willeston, who made a special investigation of this matter, says:

"The supply of oil which is available for fuel in the United States, therefore, is, first, the small percentage (probably not over 2 or 3 per cent) of the total production of the Pennsylvania and Ohio oil—the residuum from the process of refining; second, crude oil from the Ohio and Indiana fields, wherever the price of coal makes the burning of oil at 95 cents or $1 per barrel (plus freight) profitable; third, those portions of the California oil which are not best suited for refining; fourth, practically the entire output of the Texas field."

The demands for the better grades of oil for refining purposes will probably keep pace with its production; consequently we can never expect to see such grades of oil compete with coal to any large extent.

On the other hand, the refining value of the Texas oil and much of the California oil is so low that its value will probably always be largely controlled by the demand for it for fuel purposes. It is inconceivable that a fuel which has so many distinct advantages, and which is not unlimited in its supply, should sell in all markets at a price which would make it cheaper to burn than coal. Any great demand for such a fuel would bring its price up at once.

Again, so long as there is an assured supply of Texas and California fuel oil, the price of such oil that has little intrinsic value for refining will probably remain low enough to enable it to compete successfully with coal, in those regions where coal is scarce in quantity and poor in quality. And the area in which this condition exists is sufficiently wide to create a demand for the fuel oil that will soon equal the supply, unless further stores of oil are found as the demand for it increases.

(To be continued.)

* Report United States Geological Survey.

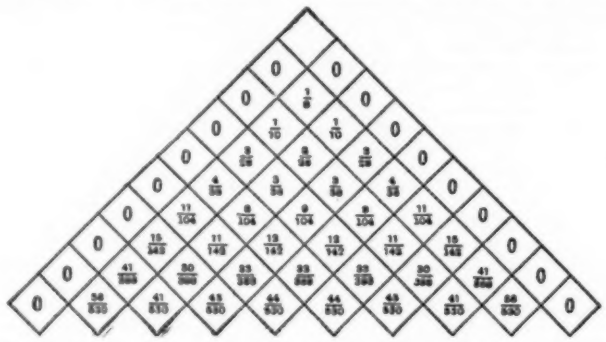


TABLE I.—SHOWING BENDING MOMENTS OVER SUPPORTS FOR A CONTINUOUS BEAM OF SEVERAL EQUAL SPANS.

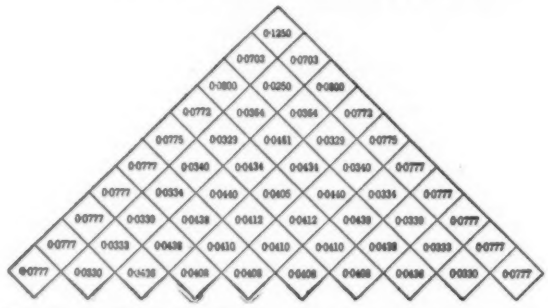


TABLE II.—SHOWING MAXIMUM BENDING MOMENTS FOR A CONTINUOUS BEAM OF SEVERAL EQUAL SPANS.

In both Table I. and Table II. the number of squares in any horizontal row is equal to the number of spans, or to the number of supports diminished by unity.

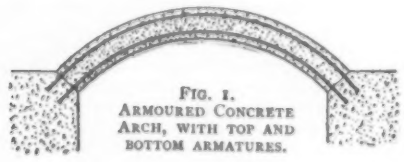


FIG. 1. ARMOURED CONCRETE ARCH, WITH TOP AND BOTTOM ARMATURES.

FIG. 2. MELAN ARCH.

FIG. 3. HENNEBIQUE ARCH.

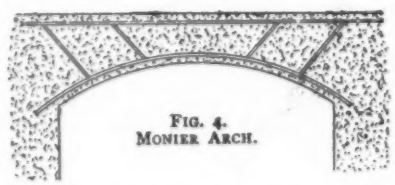


FIG. 4. MONIER ARCH.

ARMORED CONCRETE.—V.*

By LIEUT. HENRY J. JONES, A.O.D., A.R.C.Sc. (Lond.), Inspector of Ordnance Machinery.

[Concluded from SUPPLEMENT No. 1570, page 25154.]

IT will have been noticed that the common theories of armored concrete, besides being singularly irrational, are also inconclusive; they do not make clear, either qualitatively or quantitatively, the exact part played by the armoring. From any of the beam theories already given, for instance, it is not at all obvious why one per cent armoring should render a three-inch armored beam equal in strength to a nine-inch beam of plain concrete, or why the maximum deflection in the one case can safely be ten times that in the other. Maybe this obscurity is due to the fact that in nearly all cases the original beams, etc., were not built up upon any preconceived theory, but the theory was arranged to cover the general practice of any particular patentee. There is, however, a theory which, although depending upon the general assumptions common to all systems, yet utilizes them in such a way as to give prominence to the proportionate loads carried by the components, and hence to the part played by each. We refer to the theory of strain energy.

This theory is based on the generally acknowledged fact that in straining any structure only two kinds of energy are involved, namely, the strain energy of molecular displacement, and the potential energy of the applied loads. Thus the kinetic energy of the structure is neglected, its amount in all practical cases being inappreciable. From the general principles of the conservation of energy it is hence concluded, that in any strained structure the loss of potential energy, or the work done by the applied loads, finds its exact equivalent in the strain energy of the distorted structure. As illustrating the application of this theory, we may consider the case of columns and beams.

Let A = cross-sectional area of a column.
a = percentage of steel in cross-section.
l = length of column.
E_1 = Young's modulus for concrete at the safe compressive working limit.
E_2 = Young's modulus for steel.
$(w_1 + w_2)$ or w = total load carried by column, of which the concrete carries w_1 and the steel w_2.

Assuming the column to have been designed according to the rule already given governing the length and diameter, bending stresses need not be considered. If x is the total compression of the column due to the load w, then we have a column of concrete of length l, compressed by x, and a column of steel of length l, compressed by x. Now the strain energy of compression in each of these columns will be equivalent to the average force of compression multiplied by the amount of compression, hence we may write:

$$\text{Strain energy of concrete} = \frac{w_1}{2} x$$

$$\text{Strain energy of steel} = \frac{w_2}{2} x$$

$$\text{Total strain energy of column} = \frac{w}{2} x$$

$$\text{Now the compression of the concrete} = \frac{w_1 l}{AE_1}$$

$$\text{And the compression of the steel} = \frac{w_2 l}{\frac{a}{100} AE_2}$$

$$\text{Hence the strain energy of concrete} = \frac{w_1^2 l}{2AE_1}$$

$$\text{And the strain energy of steel} = \frac{100 w_2^2 l}{2aAE_2}.$$

Therefore

$$\frac{l}{2}\left(\frac{w_1^2}{AE_1} + \frac{100 w_2^2}{aAE_2}\right) = \left(\frac{w_1 + w_2}{2}\right)\frac{w_1 l}{AE_1}$$

$$\text{or } \frac{w_1}{w_2} = \frac{100}{a}\frac{E_1}{E_2}$$

In other words, the loads carried by the concrete and the steel vary directly as the cross-sections and directly as the elasticities. If we assume $\frac{E_1}{E_2} = \frac{1}{10}$, we have $\frac{w_1}{w_2} = \frac{10}{a}$. And since $(w_1 + w_2) = w$, we can determine what proportion of the total load is carried by the components of the column. If we arrange the value of a so that the steel is worked to its safe limit concurrently with the concrete, then we can determine the safe total load for a column of known cross-section, A. It has been found practically, however, that the load so calculated does not agree with the results of experience, the difference being due to the high initial stresses set up in the materials as the concrete shrinks. It is hence customary to give a a higher value than that theoretically necessary. The Hennebique columns are calculated by a very simple method. If w is the load to be carried, and A the cross-sectional area of the column determined from considerations of stiffness, etc., then, if the concrete can be worked to c pounds per square inch, and the steel to s pounds, Ac is the safe load which the concrete can carry, and hence $(w - Ac)$ is the load which the steel must carry, and the area of steel in cross-section is thus $\frac{w - Ac}{s}$. We thus see that the actual part played by the steel consists in this, that for a certain strain it is able to store far more energy than the concrete.

In the case of beams, we have somewhat similar con-

* Technics.

ditions, the load being replaced by a couple action, and the linear strain by an angle of flexure. If M is the average value of the couple acting on an elementary portion of a beam during angular flexure $\triangle\theta$, then the work done in distortion and stored in the beam as strain energy of flexure is $M \cdot \triangle\theta$, where M is the bending moment at any section of a beam. We now have from the general equations for beams,

$$\frac{M}{I} = \frac{f}{y} = \frac{E}{R}$$

and the strain energy of flexure for a small element of length $\triangle x$ is

$$\frac{M}{2} \cdot \frac{M}{EI} \cdot \triangle x, \text{ or } \frac{M^2}{2EI} \triangle x.$$

The strain energy for any one member will thus be $\int \frac{M^2}{2EI} dx$, and the total strain energy for all members

$$\Sigma \int \frac{M^2}{2EI} dx.$$

We may take the case of a beam freely supported at both ends and loaded at its center with a load, w. Then it can be shown to a first approximation that the deflection at the center, which is $\frac{d\phi}{dw}$ where ϕ is the total strain energy of the system, is

$$\frac{wl^3}{48}\left(\frac{1}{E_1I_1} + \frac{1}{E_2I_2}\right), \text{ where}$$

E_1 and I_1 respectively denote the elasticity and the moment of inertia about the neutral axis for the concrete;

E_2, I_2 being the corresponding quantities for the steel.

For a simple concrete beam, the maximum deflection at the center for the specified conditions of loading would be

$$\frac{wl^3}{48} \cdot \frac{1}{E_1I_1}$$

Hence the ratio of the maximum deflection for a compound and a simple beam of the same cross-section is

$$\frac{E_1I_1 + E_2I_2}{E_2I_2}$$

Putting $\frac{E_2}{E_1} = c$, the above ratio may be written

$$\left(\frac{1}{c}\frac{I_1}{I_2} + 1\right)$$

If b is the breadth, and d the depth of a beam of rectangular cross-section,

$$I_1 = \frac{bd^3}{12} = \frac{A_1d^2}{12}. \quad \text{Also } I_2 = \frac{A_2(d-2)^2}{4}$$

Assuming the armoring to be not more than 2 per cent, so that $A_2 = \frac{1}{50} A_1$, we have the ratio of the maximum deflections in the two cases to be

$$\frac{8d^2 - 12d + 12}{3d^2 - 12d + 12}$$

The following table gives the values of this ratio for several beams, the results agreeing very closely with experimental evidence:

Depth of beam.....	3	4	5	6	8	10
Ratio of deflections.....	16	7.6	5.6	4.7	3.9	3.6

In connection with the design of armored concrete beams and girders, Tables I. and II. are of great use. They give the bending moments over the supports, and also the maximum bending moment for a beam continuous over several supports and freely supported at the ends. The beam is uniformly loaded with w pounds per foot run, and in each case the figures given have to be multiplied by wl^2, where l is the length of the equal spans.

ARCHES.

Concrete has long had an extensive application in the building of arches, but until the introduction of armored concrete the arches that could be economically and safely constructed were limited to spans of a few feet. The general rule that the line of resistance fell within the middle third had to be observed for simple concrete arches, as for those in brickwork and masonry; and the thickness of the arches at the crown was thus approximately the same whether built in either of these materials. The introduction of steel armoring, however, made it possible not only to reduce the thickness of the ring for a given load-carrying capacity, but by suitably providing for the tensile stresses to enable arches of much greater span and smaller rise to be built. Some general types of arches in armored concrete are shown in Figs. 1, 2, 3, and 4. Fig. 1 shows an ordinary arch with top and bottom armature. In many cases where the tensile stresses can safely be carried by the concrete the top armature is omitted. In the Melan arches, shown in Fig. 2, the top and bottom armatures are connected by ligatures, and in the Hennebique arches (Fig. 3) the stirrups are used. As a general rule, hinges should be built at the springings and the crown, for the calculations are much simplified, and the line of resistance goes through the hinges; the arches also adjust themselves better to the load and to any slow temperature changes, and when the centering is struck the arch can better take its bearings without cracking. The methods of calculation for arches are as numerous as those for beams, and generally speaking are as irrational. The Monier system is the one most generally adopted, and over 400 bridges built on this system now exist on the Continent. If H_1 is the horizontal thrust, and H_2 the thrust at the springing per unit breadth, $\frac{H_1}{430}$ is taken to be the thickness at the crown and $\frac{H_2}{430}$ that at the springing; and the axis of the arch is assumed to be parabolic. Let w_1 be the dead load per foot run, and w_2 the live load; then if l is the span and h the rise,

$$H_1 = \left(\frac{w_1 + w_2}{8h}\right)l^2$$

$$\text{and } H_2 = \sqrt{\left\{\frac{(w_1 + w_2)}{2} l\right\}^2 + H^2}$$

As a general rule the Monier arches work out to about 1 per cent armoring, and the Melan arches to about 2 per cent.

GENERAL APPLICATIONS.

The general utility of armored concrete is best illustrated by the great variety of purposes for which it has been successfully employed. The material is coming to be increasingly employed for foundations, vaults, kilns, roads, bridges, tanks, sewers, conduits, dams, pavements, piers, docks, tunnels, fortifications, and canals; and in addition to general features of constructional work, such as columns, walls, floors, roofs, and arches. For the heavier kinds of work, particularly in exposed situations, it has great advantages. Thus docks and harbor works, being usually built on alluvial formations, are liable to instability through the sinking of the foundations unless an expensive system of piling is adopted. In some cases the piles not only have to inclose the site, but in reality form the site itself; and we have seen that concrete piling is in every way superior to that ordinarily used. Concrete sheet piling can also be made so as to effectually remedy the scouring of the ground beneath the walls, which leads to sinking of the walls, even though the foundations themselves may be stable. Nothing can compare with armored concrete for pipes and conduits connected with large systems of water supply or drainage. Since Bordenave first showed how to construct pipes, sewers, and reservoirs, the system has been developed to a very considerable extent, and for one system in Algeria the pipes are nearly 2 feet internal diameter, the service nearly 19 miles in length, and the pressure head safely carried is from 50 to 80 feet.

We may thus reasonably conclude that from every point of view of the constructional engineer, armored concrete has general merits which make it superior to any other material at present known to mankind. The finished work is monolithic, and settlement of the ground can be properly transmitted. The buildings also become stronger with age, require no outlay for maintenance and little for repairs, and have great permanency under varying climatic conditions.

THE DE FOREST SYNTONIC SYSTEM OF WIRELESS TELEGRAPHY.

By A. FREDERICK COLLINS.

IN April, 1903, there appeared an article* by the present writer describing at length and in detail the system which Dr. De Forest and his colleagues had devised and were using at that time. During the elapsed period a great deal has been learned about this mode of electric transmission and thus arrangements that were considered orthodox have undergone a very considerable change until, had we been dealing with creeds instead of physics, the cry of heresy would certainly have been heard ere this.

Of the improvements that have been introduced in this American system that of syntonization may be cited as being the most important, while the principles upon which it is based have not been touched upon, much less utilized, in previously constructive arrangements in which resonance is a factor. This may be readily observed by those who are familiar with the work of contemporaneous wireless workers, for De Forest employs a system of distortionless wires obtained by a modification of Lecher's wires.†

An experimental apparatus of this type was used by Hertz for showing the mechanical action of electric waves in wires‡ and a verbatim description as given by him will serve to make clear its application to syntonic wireless telegraphy. Referring to Fig. 1, then, $A\,A'$ is an oscillator formed of two square plates of copper or zinc, each 40 centimeters in the side, and connected by a wire 6 centimeters long, divided in the middle so that a spark-gap 2 millimeters long results. The opposite arms of the oscillator are excited by a small induction coil, energized by a current from two accumulators. The coil used gave a maximum spark length of only 4 centimeters, but though Hertz found that single discharges of this smaller apparatus were less efficient than those of a larger induction coil, the drawback was more than compensated for by the more rapid succession of discharges.

Opposite the plates A and A', and at a distance of 10 centimeters from them, stood the plates B and B', from which two parallel wires about 30 centimeters apart are led to a distance of 6.8 meters, and these are connected together between b and b'. At a variable distance $a\,a'$ from their origin these wires are placed in communication with each other by means of a second connection or bridge. When this bridge is in a certain position at a distance of about 1.2 meter from $B\,B'$, there takes place in the interval between $a\,a'$ and $b\,b'$ a very energetic oscillation. This indicates the half wave-length of a stationary wire, and, as Herr Lecher has shown, it is produced by resonance between this oscillation itself and the primary oscillation, which here takes place in the interval between $A\,A'$ on the one hand and $Ba\,a'B'$ on the other hand.

Any shifting of the bridge increases one of the two periods of oscillation, and at the same time diminishes the other; hence the peculiar definiteness of adjustment with this arrangement. The experiments performed by Hertz with this apparatus enabled him to determine the magnetic as well as the electric forces of the oscillations, and that the velocity with which they were propagated along a wire was identical with those of light waves. He also conducted a research to determine the wave length in wires. Assuming now that the system of wires is energized with electric oscillations of high frequency, these will traverse the conductor if the latter is one-quarter or any multiple of one-quarter of the wave length of the impressed oscillations, and on reaching the end of the wire these will be reflected back to the opposite end from which they started.

The phenomenon involved in stationary waves is brought out very clearly by Poincaré in his admirable explanation of Maxwell's theory,* of which the following is an excerpt: Suppose a periodic disturbance to travel along a wire; when it reaches the end of the wire it will be reflected and will return in the opposite direction. The resulting disturbance may be obtained by combining the direct and reflected waves. Two periodic waves are added together when they are of the same phase, that is when the alternating currents which accompany them are both positive or both negative at the same time; they annul each other when they are of opposite phases, that is, when the currents accompanying one are positive while those of the other are negative and *vice versa*.

The two waves, direct and reflected, are of the same phase, and are added if the difference between the distances which they have traveled is an integral number of wave lengths, when the corresponding points of the wire where the action is a maximum are called "loops." The two waves are opposite in phase and mutually destructive when the difference between the distances traveled is an odd number of half wave lengths; the corresponding points of the wire where the action is *nil* are called "nodes." The difference between two consecutive nodes is equal to half a wave length.

Let A and B be two such nodes, shown in Fig. 2; at A the distances traveled by the two waves is equal to an odd number of half wave lengths, say $2n + 1$. The direct wave passes A before reaching B, while the reflected wave passes B before reaching A. When moved from A to B, the distance traversed by the reflected wave is diminished by $A\,B$; thus the difference between the distances traveled is diminished by $2 \times A\,B$. Now as the point B is a node, this difference must also be an odd number of half wave lengths, $2n - 1$; thus $2 \times A\,B$ must be precisely equal to a wave length.

Such is the phenomenon of stationary wires as it was evolved by Hertz, who was striving for a simple method of measuring wave lengths. Reflection at the end of a wire may take place in different ways; if the wire simply ends abruptly without capacity, as for example if the parallel wires shown in Fig. 3 are connected to the opposite plates of a condenser, then the end is a loop; again, the ends of these two adjacent and parallel wires may be joined; in this instance a wave which has traversed one of the wires in the positive sense returns by the other in a negative sense and, interfering with the positive wave following on the second wire, stationary waves are produced.

It will not be necessary to touch upon the conclusions of MM. Saracin and De la Rive, who formulated the law of multiple electric resonance, but there are yet some vital points that should be brought out in order to give the work of Dr. De Forest its full significance. These have been cited at length and in considerable detail in his patent specification.

In open circuit systems of wireless telegraphy the failure to attain the efficiency desired is largely due to the fact that the waves emanating from the aerial radiator are rapidly damped out or decreased in intensity or amplitude; that is to say, while the maximum intensity of the waves may be satisfactory, their persistency is quite the reverse, as they fall in amplitude to 0. In consequence of this, their energizing action upon the receiving antenna being repeated but a few times per unit of time, they do not have nearly the cumulative energizing effect that a much feebler impulse would have, if it were repeated a greater number of times in the same interval.

In the device under consideration, means are provided for producing each signal by a longer and better sustained series of wires, the same arrangement lending itself admirably to the receiver, in the use of which it has special and marked advantages. Now in Lecher's wires, where the adjacent and parallel conductors are of equal length, and each is connected with a terminal of any form of apparatus capable of producing high-frequency electric oscillations, the energy at any point of their length is of exactly equal intensity and of opposite phase. The currents flowing in these two wires are also at corresponding points equal in amount, and flow in opposite directions. If these wires are the equivalent of one-quarter, or any multiple of one-quarter, of the wave length of the oscillations traversing them, reflections will occur that are highly efficient, as has been previously shown, set up stationary or standing waves.

The system is then divided up into quarter or half

* Electrical World and Engineer, April 11, 1903.

† E. Lecher, Wiedemann's Ann., 41, page 850, 1890.

‡ Electrical Waves, Hertz. Translated by Jones, Page 187, 1900.

* Maxwell's Theory. Translated by Vreeland.

wave lengths, with nodes and loops symmetrically located on each wire. The potential of the dual wires forming the system will be precisely the same at any similar point, but one oscillation will be positive and the complementary one will be negative, while the currents of these oscillations will be propagated in a direction opposite one another, and at points that correspond to each other. Since there is a phase difference of a

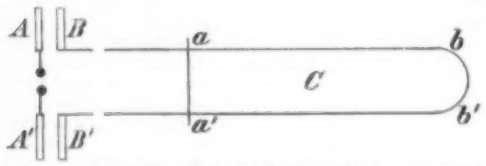


FIG. 1.—SYSTEM OF LECHER WIRES USED BY HERTZ.

quarter of a wave length between the electrostatic energy and the electromagnetic energy, the current will be maximum when the potential is minimum, and the reverse. For example, let Fig. 4 represent the usual system of wires, and let *A B C* and *D E F* represent lengths equal to one-half a wave; the distance between these points will then be equivalent to a quarter of a wave. Now oscillations set up in these wires will have loops of potential or electrostatic energy at some points

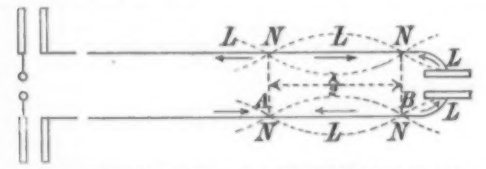


FIG. 2.—FORMATION OF STATIONARY WAVES IN WIRES ENDING IN A LARGE CAPACITY.

and nodes at others, as shown by the dotted lines, and current or electromagnetic energy at intermediate points, as indicated by the continuous lines. It is evident then that whenever a maximum difference of potential occurs forming a loop, there the current will be 0; and if a detector is of the voltage-operated type, it should be placed at *C*, whereas if it is a current-operated device it should be inserted at *E*.

It may be further added that by bridging the parallel

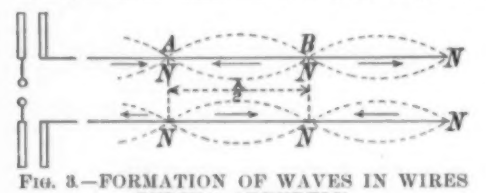


FIG. 3.—FORMATION OF WAVES IN WIRES ENDING ABRUPTLY.

conductors at *B b* or at *E e* with wires, no untoward effects are produced on the potential of the oscillations, and the system may even be grounded at these points without any appreciable result, except that all oscillations of a faster or slower period will be conducted to earth.

The theory of the parallel system of conductors, as deduced by Lecher, Marx, Lord Rayleigh, Heaviside,

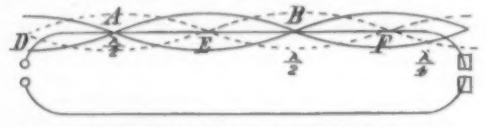


FIG 4.—FORMATION OF CURRENT AND POTENTIAL WAVES SHOWING LAG OF 90 DEG.

Black lines, current energy. Dotted lines, potential energy.

and Bjerknes, shows that the inductance and capacity of the simple wire system and of the wire and sheath return, i. e., a wire surrounded by a co-axial tubular conductor, from which it is insulated and which is really a special form of Lecher wires, are evenly distributed and are reciprocals per unit length of the system; that is to say, the capacity and inductance cancel each other in so far as the dimensions of the wire are

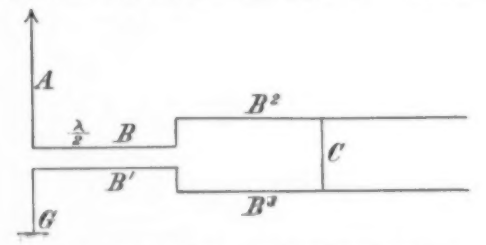


FIG. 5.—DE FOREST ARRANGEMENT OF AERIAL AND PARALLEL WIRES.

concerned, and that the period of oscillation is independent of the distance between the two wires and their diameters.

Such a system of conductors is termed a distortionless circuit, and on it the velocity of propagation of high-frequency oscillation is approximately that of light; for instance, this is the velocity when the inductance is the reciprocal of the capacity per unit length, and these conditions are satisfied when the wires are less than one-half millimeter in diameter and less than 100 meters in length. The formula for the inductance

$$d$$

per unit length of the Lecher wires is $L = \text{log. nat.} \frac{}{r}$,

where d is the distance between the centers of the two parallel wires and r their common radius. The expression for the capacity per unit length is the reciprocal of the above, or $S = \frac{1}{L}$; hence the remarkable property of the Lecher system, in which the velocity of propagation of an oscillation along its length is independent of the size of the wires or the distance between their centers, and this rate of speed is equal to the velocity of light.

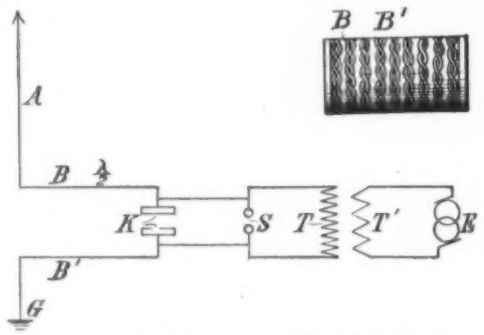


FIG. 6.—DE FOREST SYNTONIC TRANSMITTING SYSTEM.

The relative quantities of electromagnetic and electrostatic energies depend wholly on the ratio of L to S. Where the inductance is large and the capacity small, there will be a greater proportion of the total energy developed as inertia or momentum; oppositely, where the capacity is large and the inductance is small, there will be a greater proportion of energy developed in elasticity. It will now be understood how the period of any section of a Lecher system embraced between

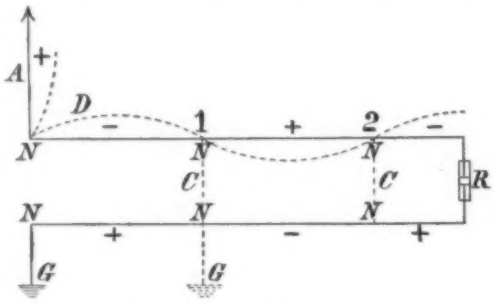


FIG. 7.—DE FOREST ARRANGEMENT OF LECHER WIRES AND ELECTRIC WAVE DETECTOR.

two consecutive bridges is a junction of the length between said bridges alone. Hence in the arrangement shown in Fig. 5 the velocity of propagation along the wires between *B B'* is identical with that along the section $B^2 B^3$, and if the length of these two sections is the same, the period of oscillation will be the same; but although the product of inductance and capacity will be the same for both, L will be small in *B B'* and large in $B^2 B^3$, while S is large in *B B'* and small in $B^2 B^3$. It is evident then that in passing from *B B'* to $B^2 B^3$ there is a transformation from electrostatic to electromagnetic energy; that is, when the charges that are traversing *B B'* are transmitted to $B^2 B^3$ respectively, where the capacity is less, the potential difference must be increased, and *vice versa*.

On account of losses from resistance, leakage, and imperfect reflection at bridges or open ends in such a

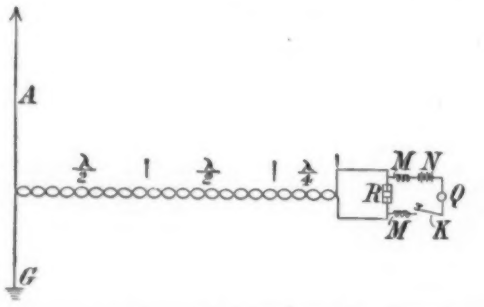


FIG. 8.—DE FOREST SYNTONIC RECEPTOR SYSTEM.

system of parallel wires as is here described, the stationary waves set up therein are never perfect, and therefore absolute nodes are never found in practice, although with suitable reflecting devices the approximation is sufficiently close when a slowly damped wave train is transmitted. For this reason the points of maximum and minimum difference of potential and of current are largely dependent on the coefficients of resistance, leakage, and reflection. Ordinarily, the order of magnitude of the energy involved in the two sets of waves, namely, the electrostatic and electromagnetic, is the same, and if the parallel wires were infinitely small in diameter, the magnetic force must equal the electric, and the greater the surface the less becomes the magnetic force relative to the electric, the one increasing as the other decreases.

The characteristics and advantages of the Lecher system are: (*a*) that it is to a high degree a resonant oscillator, i. e., it has a very marked period of its own, and is very little responsive to oscillations of any other frequency than its own; (*b*) it is a poor radiator, and consequently a persistent oscillator, therefore the energy is damped out slowly, the resultant effect being a long wave train. This is due to the fact that most of the lines of force lie in the space between the two conductors, and the radiation losses are consequently small, except when a radiator is attached, as may be observed when it is stated that the observable magnetic effect from a Lecher system, according to one authority, even when strongly excited, does not extend beyond three centimeters from the parallel wires; (*c*) by reason of the stationary waves set up, higher potentials are obtainable than would otherwise be possible; (*d*) the nodes and loops of these stationary waves are fixedly located, thus enabling connections to be made with wires at any phase of the wave desired; (*e*) the system may be easily and accurately tuned to any frequency desired; (*f*) it is simple in its mathematical and theoretical aspects; its constants are easily calculated and controlled, so that the dimensions of a system for securing definite results may be easily predetermined. This has always been a difficult procedure in other forms of apparatus employed in connection with high-frequency currents, such as are employed in wireless telegraphy.

Now Dr. De Forest found that these characteristic features of the Lecher system of wires renders them especially adaptable for use in sending and receiving wireless apparatus, for they are extremely flexible, easily adapted to such modification as may be required by circumstances, as the type of transmitter or receiver employed and the practicable dimensions of the apparatus, as the height and character of the upright wire.

Fig. 6 shows an apparatus designed by De Forest for utilizing the foregoing principles as a sender; there are several modifications, but the one illustrated is a typical form. This is termed a static method of excitation, and in it the parallel or Lecher wires are indicated as of only one-half wave length; inserted in the bridge across their ends is a condenser *K*, while in shunt around this condenser is the spark gap *S* and the secondary coil *T'* of a transformer *T T'*. When this condenser is changed to the breaking-down point of the spark gap by a suitable source of energy, as an alternating-current generator, a discharge occurs, and this serves as a connecting bridge between the parallel wires when oscillations are set up in these wires, as in the usual Lecher system. Part of the impressed energy is reflected back at *O* and *O'*, forming stationary waves with nodes at *O* and *O'*, while another portion goes to the aerial wire *A* and is damped out in the form of electric waves.

In other forms of this type of transmitter, the Lecher system is charged inductively, that is, the secondary of the transformer is in the circuit of the parallel wires, and therefore the impressed energy oscillates through it, whereas in the arrangement shown in Fig. 8 it is not in circuit with it, and the oscillations do not surge through it. The transformer, it is pointed out, may be replaced by any source of electrical energy possessing the requisite potential. Sometimes it is desirable to have the parallel wires equal to one quarter of a wave length and the secondary of the transformer coil equivalent to a one-half wave length. In such a case the primary coil of the transformer is connected in series with a pair of condensers and the spark gap, when the primary system is changed from any suitable source of energy. In this form it is necessary that the inductance of the primary coil of the transformer and the capacities of the condensers be of such values that the natural period of oscillation of this primary system is equal to that of the adjoining Lecher system.

That the length of the parallel wires may be reduced, a condenser can be connected across them at that portion in which the oscillation forms a static loop, i. e., one-fourth of a wave length from the base of the aerial wire. A condenser so located is the equivalent of a certain length of the parallel wings, so that a system which includes the condenser oscillates with a period of one having longer wires or reduces the length of the wires necessary for a given period. The effective capacity of such a condenser depends chiefly upon its position relative to the stationary wave, being most efficient when located at a static loop, that is, the point where the potential difference is maximum across its terminals are maximum.

It has been observed that a capacity formed of a condenser placed across the Lecher conductors exerts a greater or lesser distortion and absorption of the waves according to its proximity to an electrostatic loop or a node; if located near a loop the potential difference across its terminals is greatest and consequently the quantity of electricity capable of being stored is correspondingly increased while the effect of storing up energy at such a point is proportional to the position of the condenser in the system, or in other words while the absolute capacity is independent of this location its effectual or equivalent capacity is dependent on it.

In Fig. 7 is shown a complementary receiving system

formed by a combination resonator comprising an aerial, a ground, a pair of Lecher wires and a detector. In this arrangement which is characteristic of the De Forest receivers the wire *B* is connected with the aerial wire or antenna *A* and the parallel wire *B'* is connected with the ground *G* or other capacity. The equivalent length of the aerial wire is one-quarter of the wave length of the natural oscillation to which the system is tuned. At a distance of one-half a wave length from the base of the antenna, on the Lecher wires, marked by the numeral 1, occurs the first node, and if the wires are long enough other nodes will be found separated by the same distance as the node 2. At these nodes, as cited earlier in the text, the parallel wires may be connected by no-resistance bridges as *C C*, not only without destroying but without seriously affecting either the oscillations or the propagation of the waves; and these bridges may also be grounded as shown by the line at *G'* without affecting the period of oscillation.

If the wires are extended one-quarter of a wave length beyond the last node, a loop of electrostatic force will be formed by the open end reflection. At such inclosed ends all of the energy of the system is electrostatic and therefore if a detector of the type utilizing a difference of potential, viz., a voltage operated device as a coherer, is inserted at a static node it will work with the maximum efficiency. The dotted lines indicate the position and intensity of the oscillations in the system. A detector is shown at *R* inserted between the open ends of the Lecher wires, but it can be placed wherever a node occurs. A current-operated detector should, on the other hand, be placed at the loop of the electromagnetic oscillation, as the voltage and current waves, as previously stated, are distant one from the other a quarter of a wave length or 90 degrees.

Owing to the fact that the ordinary antenna is a strongly damped oscillator and the system of parallel wires attached to its base is a feebly damped oscillator, it sometimes occurs that a violent oscillation received by the aerial wire may produce in the parallel conductors oscillations having the distinctive period of the former, without regard to the period of the exciting impulse. If this impressed energy is in the form of a long train of waves, then interference in the parallel wires would arise, and the effect above described could not take place. Oppositely disposed, if this long wire train has a frequency equal to that of the wire system, the latter would be violently excited. It is evident then that by regulating the sensitiveness of the receiving device or detector it would be possible to cause it to respond only to those wires emitted by a previously syntonized transmitter.

Other modifications of the receiver may be had by resorting to the wire and sheath return wherein, as in the parallel Lecher wires, the inductance and capacity are also evenly distributed. When this form is utilized in practice the wire connecting with the antenna is insulated and incased in an outer tubular conductor, the latter being connected to the ground connection. The wires travel upon the outer surface of the inner conductor and break on the inner surface of the outer conductor. Another form is to replace the aerial wire by a large metal cylinder, which is connected to one of the parallel wires, while an inner conductor connected with the opposite wire leads to earth.

To reduce the actual length of the Lecher wire system required to form the equivalent of the proper wire length, so that it may be used in the practice of wireless telegraphy, inductance coils are inserted in the parallel wires of the transmitting system; these coils should be placed at the loops of the current energy where their inductance will be maximum, and if the wires are bridged, these should connect to the middle points of the two corresponding coils. Condensers are also utilized at the base of the aerial wire as well as at the static nodes of the parallel wires as lag-producing and period-adjusting arrangement, and by these means the usual long wires are shortened up into a very compact device.

In Fig. 8 is shown a practicable form for using the Lecher wires as a receiver. The two wires which are insulated are twisted together, the distance between them being determined by the thickness of the insulation. The pair of wires thus twisted is well adapted to be wound on a spool or coiled in any other manner in order to economize space and to secure portability. If the two simple parallel wires introduced were wound on a spool with convolutions parallel and near each other, interference by induction between the adjacent turns would be set up; but when closely twisted the turns of the wires if not too close together will not interfere with each other. If the twisted wires are of any considerable length, the convolution of one wire will first lie adjacent to another, carrying a current of like sign and then to one carrying current of the opposite sign, so that the inductive effects from the two wires in the adjoining convolutions will be neutralized.

In practice Dr. De Forest has successfully used such wires twisted with a pitch equal to three turns to the inch wound on a spool about three inches in diameter with the successive turns separated about an eighth of an inch. While it is desirable that the pitch and twist be not too steep, their use is not by any manner of means limited to the proportions named. This is the first time as far as the writer is aware that the advantages of the Lecher wires as a tuning and syntonizing device have ever been employed in wireless telegraphy. It is pointed out by the patentee that it practically retains all the theoretical advantages of the straight parallel wires embodied in a compact form, which makes the apparatus portable and practicable. Thus have the researches of Hertz, who determined the electric and magnetic forces in parallel wires, found a new and wonderfully ingenious application in an art for which he did more than any other one man.

CONTEMPORARY ELECTRICAL SCIENCE.*

PRODUCTION OF OZONE BY ULTRA-VIOLET LIGHT.—According to Lenard, ultra-violet light converts oxygen into ozone when shining into it through quartz, but the production of ozone ceases as soon as a plate of mica is interposed, which is impervious to ultra-violet light. In Siemens ozone tubes ultra-violet light is generated by the silent discharge, and is probably the cause of the production of ozone in them. To determine the manner in which the light operates, F. Fischer and F. Braehmer have done some work with a special form of mercury arc lamp provided with a quartz end-piece. By cooling the oxygen tube with a freezing mixture, they succeeded in bringing the percentage of ozone up to 0.258. The speed of the current of gas is an important factor. The quicker the gas is passed on, the more it tends to cool the vessel, and the less likely is the ozone in it to decompose. Thus, although in a quick current the actual percentage of ozone is lessened, the net efficiency of the light is increased. As soon as the temperature reaches 270 deg. C., the ozone is decomposed. The temperature of the mercury arc is also of moment, as a slight difference often materially alters the percentage of ultra-violet light.—Fischer and Braehmer, Physikalische Zeitschrift, September 15, 1905.

ELECTROMAGNETIC SCREENING.—Kunito Ogawa has measured the screening effect of a conductor upon a metallic circuit in some simple cases. If a conductor is placed in front of the circuit so as to shield it from the train of impinging waves, the screening effect of the conductor increases with its own conductivity and with the frequency of the oscillations. The author interposed either a metallic loop or a piece of gold or silver foil in the path of the waves. He measured the resonance current by means of a calorimeter composed of a small glass bulb with a stop-cock and a capillary U-tube attached. A thin wire was stretched across the bulb, and formed part of the resonating circuit. Any current traversing this wire heated it, and the amount of heating was indicated by a displacement of level of the water in the U-tube. The metallic loops were of copper wire, and had resistances ranging from 0.004 to 0.722 ohm. It was found that they screened off from 40 to 20 per cent of the impinging wave energy. At the higher resistances the screening effect seems to approach a minimum. Gold foil 10^{-3} millimeter thick screens off from 7 to 18 per cent as the frequency increases from 200,000 to 1,600,000 per second. Silver foil of double that thickness screens off from 38 to 50 per cent.—K. Ogawa, Memoirs of the College of Science and Engineering, Kyoto Imperial University, Vol. I., No. 2, 1904-5.

POINT DISCHARGES IN PURE GASES.—Electric conduction in gases has been considerably elucidated since the conception of ionization has been applied to its theory. A weak point of the theory is still, however, the point discharge, which, though studied by Warburg, Campbell, Chattock, Röntgen, Sieveking, Tamm and Precht, among others, has not been theoretically worked out except to some extent by Stark. The reason probably lies in the paucity of materials accumulated under test conditions, and to remedy this defect P. Ewers has undertaken a long series of measurements in monatomic and diatomic gases under conditions likely to secure the greatest attainable purity. The gases examined were helium and argon as monatomic specimens, and hydrogen and nitrogen as representatives of the diatomic class. The author is able to extend Röntgen's law to monatomic gases, and to declare that the product of the minimum potential and the square root of the mean free path, divided by the root of the number of atoms in the molecule, is nearly the same for all gases under standard conditions. He finally arrives at the simple rule that for various barometric pressures and for any given E.M.F. the current through the gas is simply proportional to the mean free path of the molecules, a rule which allies gaseous conduction to metallic conduction on substituting electrons for molecules.—P. Ewers, Annalen der Physik, No. 10, 1905.

PHOSPHORESCENCE OF ZINC SULPHIDE.—Among the substances whose luminescence is sufficiently bright for spectrophotometric study Sidot blende, or phosphorescent zinc sulphide, seems especially well suited to bring out the relationships that doubtless exist between different types of luminescence; for not only is this substance excited to luminescence by all known existing agents—light, Röntgen rays, radium rays, cathode rays, etc.—but the stimulating effect of heat, and the property possessed by the red and infra-red rays of suppressing phosphorescence, are exhibited in unusual degree. The similarity between the effects of ultra-violet light and those of Röntgen rays as exciting sources is worthy of note. In each case the chief luminescence is in the extreme violet, and is of short duration. But in each case also this is accompanied by luminescence in the green, which is relatively faint but of long duration. As is illustrated in numerous other cases, the Röntgen rays, when comparable at all with rays of light, are rather to be compared with ultra-violet light than with the rays of the visible spectrum. E. L. Nichols and E. Merritt find that the green band is most brilliantly excited by the violet, although rays from all parts of the ultra-violet spectrum are also capable of producing a considerable effect. Thus there is the same general relation between the position of the luminescence spectrum and that of the exciting light as in the case of fluorescence, and Stokes' law is violated in both cases. As regards the change of color often observed as phosphorescence dies away, the behavior of Sidot blende is typical, and in no case of phosphorescence is there any change in the form of the spectrum during decadence. In complex cases of phosphorescence this does not mean that the phosphorescence spectrum as a whole remains unchanged in form, but rather that the distribution of intensity in each band is unaltered. If the phosphorescence consists of several bands, it is to be expected that the different bands will decay at different rates. In fact Sidot blende itself furnishes an extreme illustration of this, for the violet bands die out in one or two tenths of a second, while the green band persists for hours. Numerous cases in which the color of a phosphorescent substance seems to change as the phosphorescence dies out at first appear to contradict this view absolutely. But in these cases there is either a multiplicity of bands decaying at different rates as in anisic acid, or the eye becomes color blind at the lower intensities.—Nichols and Merritt, Physical Review, October, 1905.

DIELECTRIC CONSTANT OF AIR.—A. Occhialini has determined the specific inductive capacity of air at pressures up to 200 atmospheres, using a glass condenser of variable capacity for comparison and a 7-horse-power electric motor for the compression. He corroborates Mossotti's formula—

$$\frac{K-1}{K+2}\frac{1}{D} = 0.00016$$

for all pressures examined. Applying it to liquid air, he obtains 1.475 for its dielectric constant. He admits that the structure of liquid air may offer other points of difference besides mere density, but the value deduced is not far from Dewar's actual value, 1.495.—A. Occhialini, Physikalische Zeitschrift, October 15, 1905.

RESISTANCE OF SUBMERGED WIRES.—When thin bare silver wires are immersed in flowing water kept at a uniform temperature, and the current through them is gradually increased, the resistance decreases at first and then increases again. This phenomenon has been discovered and studied by E. Rogovski, who finds that the current for minimum resistance of a wire 0.87 millimeter in diameter in water of 16 deg. C. is 2.6 amperes. He gives a satisfactory explanation, based upon the presence of a molecular layer of water adhering to the wire. This layer prevents the temperature of the wire from becoming that of the surrounding water. It allows it to rise above it, and the resistance measured is not that of the wire at the temperature of the flowing water, but the resistance at a temperature a few degrees higher than that, and therefore greater than the value sought. When the current becomes stronger, the difference of temperature on both sides of the molecular layer increases, and when it becomes about 4 deg. the layer breaks up and allows the water to flow in immediate contact with the wire. The resistance of the wire is then the true resistance at the temperature of the water. In determining the resistances of wires at various temperatures this source of error should be guarded against.—E. Rogovski, Comptes Rendus, October 16, 1905.

ORIGIN OF ATMOSPHERIC ELECTRICITY.—H. Gerdien reviews at length the theories hitherto advanced to account for the negative charge of the earth and the positive charge of the atmosphere. Elster and Geitel's theory was based upon the action of vegetation in modifying the electric field near the earth's surface, whereas Ebert's theory dealt chiefly with ionization underground by radio-active substances, and the penetration of ions, chiefly positive, into the atmosphere. The author now shows that both these theories leave much to be desired, and advances a new theory based upon the action of ions of whatever origin as condensation nuclei. It is known that negative ions have a greater condensing action than positive ions. In any drop of rain there is as a rule more negative than positive electricity. The positive ions themselves act as condensation nuclei at a sixfold supersaturation, but the author calculates that at an approximate height of 3,800 meters above the earth's surface there is a large preponderance of negative condensation. Those positive ions that are not precipitated are repelled upward, and when they reach an altitude of some 7,000 meters they are rapidly borne away by the high winds, and serve to generalize the positive charge of the whole atmosphere. In spite of this, there will be a minimum potential gradient over rainless districts, as is actually observed in Northern Africa.—H. Gerdien, Physikalische Zeitschrift, October 15, 1905.

CHARGING ACTION OF RÖNTGEN RAYS.—The discharging effect of Röntgen rays has been known from the first. That they are also capable of charging bodies has been maintained by Righi and emphatically denied by others. K. Hahn has made a careful study of the whole matter, and has placed the charging action of the rays beyond a doubt. The disagreement of previous observers is due to the masking action of secondary Röntgen rays, which must be avoided to show the phenomenon in a pure manner. All bodies impinged upon by Röntgen rays acquire a positive charge. The pulse is absorbed in the body, and breaks down some valency bonds, setting free both positive ions and electrons. If the pulse is strong enough, it will project some of the ions outside the metal, and mostly the electrons, whose mass is small. Their projection leaves the metal negatively charged. The charge acquired increases for the first 20 seconds and then remains stationary. Hard rays are most effective in charging. A high atomic weight also facilitates the charge. The author believes that his results decide

* Compiled by E. E. Fournier d'Albe in the Electrician.

the controversy with regard to the nature of the γ-rays of radium. Paschen regarded these as very rapid cathode rays. Their charging action may be explained on the above consideration when they are regarded as ether pulses. They are the counterpart of Röntgen rays, and give rise to secondary cathode rays on impact.—K. Hahn, Annalen der Physik, No. 11, 1905.

A GASOLINE-MOTOR-PROPELLED ROLLER.

By the English Correspondent of SCIENTIFIC AMERICAN.

AN interesting application of the gasoline motor to an agricultural machine has been carried out by Messrs. Barford & Perkins, of Peterborough, in conjunction with the Simms Motor Manufacturing Company, of London.

This latest development, as shown in the accompanying illustration, comprises a combination of the Barford & Perkins patent water-ballast roller with a Simms gasoline motor, of the same class as is used in automobiles. A single-cylinder vertical motor is employed, developing 8 horse-power on the brake. The engine is entirely automatic in its action, and is fitted with the Simms-Bosch magneto-electric ignition, in which device the spark for igniting the charge in the cylinder is obtained from a magneto-electric machine of special construction with oscillating sleeve, the motor itself imparting the necessary motion to the machine from the main shaft, thus producing its own igniting spark instantly and at any speed. There is no open flame whatever, consequently no danger of fire or explosion; neither is there heat, noise, nor smell. By means of a constant-level float-feet, the supply of gasoline to the motor is rendered entirely automatic, no regulation of mixing valves being necessary. Mechanically-operated valves both inlet and exhaust are fitted. The inlet valve is operated off the same shaft as the exhaust valve, and this insures regularity and silence in running and maximum efficiency at any speed.

The roller consists of two cylinders, the forward one being coupled to the motor frame by a steering head and bridge. The rear or main roller is of the water-ballasted type, enabling any desirable weight to be easily obtained either by the addition or withdrawal of water from the cylinder. The roller is of 36 inches diameter by 42 inches in length and has outside rounded edges. The total weight of the roller with the rear cylinder empty, but with everything in working order, is 2 tons 15 hundredweight, of which 1 ton 19 hundredweight is on the back roller and 16 hundredweight on the front. With the main roller filled with water the total weight is raised to 3 tons 4¼ hundredweight, all the additional weight, of course, being on the rear roller.

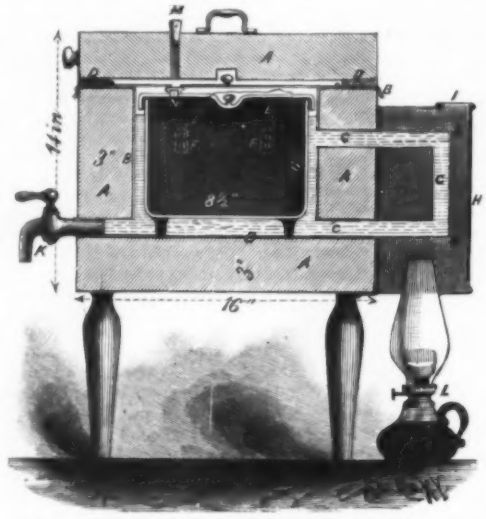
The small and compact nature of this motor renders it especially adaptable to an agricultural machine of this class. The extreme height is 22 inches, while it is 19¼ inches wide and 18½ inches long. The engine has a piston bore of 100 mm. (3.93 in.) and a stroke of 110 mm. (4.33 in.). The flywheel weighs 50 pounds, while the total of the motor, including vaporizer, magneto, etc., ready for running is 150 pounds.

The engine is mounted on a stout channel-iron frame stiffly braced together to render it rigid. The motor is water-cooled, and owing to the facilities for carrying a large body of water for this purpose, it is possible to obtain adequate and efficient cooling without either the use of a fan or radiators. The tank is conveniently placed over the rear roller, so that its weight is in a useful position, while at the same time, owing to the engine any intermediate speed can be obtained. Reversing is readily accomplished by means of three machine-cut bevel gears combined with a jaw clutch moved by a lever within easy reach from the driver's seat. The reduction of speed from the motor to the axle of the main roller is obtained in three steps, the first two being by means of spur gearing, the higher speeded gears having machine-cut teeth, and the third step by a chain connected directly to a sprocket on the main roller cylinder. Both steering and chain are of ample strength, having been calculated to stand shocks and strains considerably higher than those encountered in ordinary work.

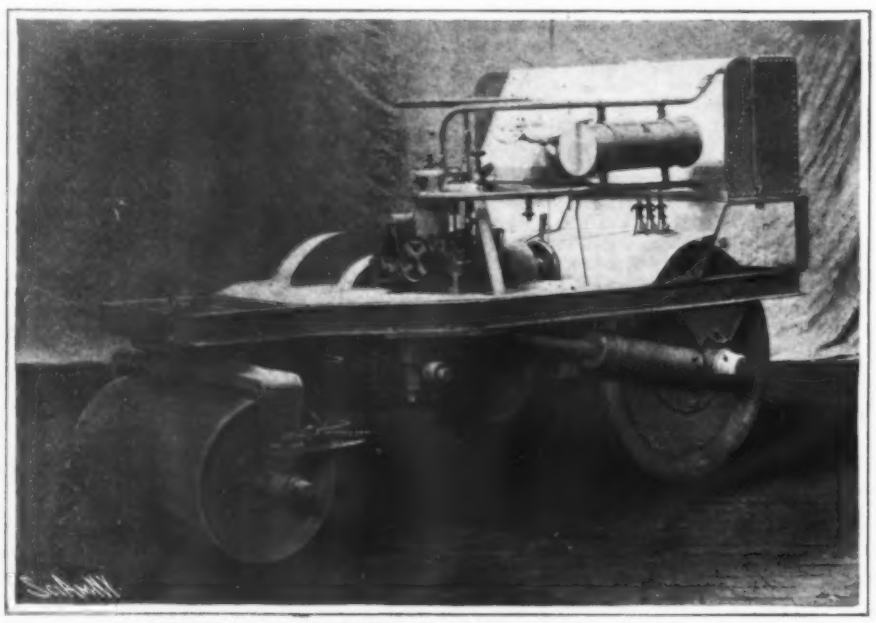
The steering is by means of a vertical pillar, the driver having perfect control through the hand wheel in front of him, which is connected by means of a chain to the steering cylinder. The bridge spanning the front rollers allows a considerable oscillation of the latter when passing over stones or other obstructions without affecting the level of the main frame, thereby reducing strains to the latter.

The utility of such an appliance is obvious. In the first place, far more work can be accomplished by its aid in a given time, with a resultant economy both in cost and labor. Furthermore, no damage is inflicted on the turf or material which is being rolled by footsteps, and it also enables operations to be carried out under adverse climatic conditions, such as after a heavy rainfall, when the ground is soddened, rendering height at which it is placed, the pressure feed to the cylinder jacket is sufficient to render a pump unnecessary, circulation being entirely automatic.

The engine is provided with a friction clutch, which allows the motor to run free for starting, and when running it can be instantly released at will. Two speeds forward and reverse are provided, viz., 1 mile and 3 miles an hour, the change being conveniently made from the driver's seat. By varying the speed of the ordinary operations impossible. This is the first application of the gasoline motor to such an agricultural machine, and its demonstration at the recent Royal Agricultural Show in London occasioned widespread interest. The idea should be possible of extension to rollers for heavier and more general grades of work, since the gasoline engine is more convenient in handling and more economical in operation than the steam engine.



A, box made of pine wood, 1¼ by 3 inches thick, according to size of cooker; B, lining of tin or tinned copper, fitted with arm, B′, of copper, through which the water, G, circulates and in which it is heated by the lamp, L; the cooking vessel, which may be of metal—preferably of porcelain or of glass. D D, felt lining to cover; E, cord attached to perforated ears or rings, F F; G G G G, water in circulation, heated by lamp, L, to about 200° Fah.; H H, hood of tin around the arm, B′ B′, to concentrate the heat upon it; I, vent to tin hood for draught; J, tin guard to keep heat from wood; K, faucet to draw off water; L, lamp with wick, ½ to 1 inch wide, according to size of cooker; M, orifice for thermometer; N, orifice to cooking vessel, with screw cap, for thermometer; B′ B′, arm, 3 in. by 1 in. deep. Rounded corners desirable inside for convenience in keeping clean. Begin with tepid or cold water if glass vessels are made use of.



A GASOLINE-MOTOR-PROPELLED WATER-BALLASTED ROLLER.

THE ALADDIN COOKER.

By EDWARD ATKINSON.

THE theory of this cooker is to accumulate heat from a common hand lamp inside a pine box, the walls of which are thick enough to retard radiation, so as to cook such food as may be placed in the cooking chamber or oven, in a thorough manner. All meats, birds, or fish may be thoroughly cooked in their own juices, only a little water being added so as to make a good gravy. Oat meal, corn meal, and farina can be cooked with a suitable quantity of water. Fruit, cheese, and such vegetables as do not require heat above the boiling point, may also be cooked in the apparatus. The juices of meat may be drawn for soup or broth by immersion in cold water in the chamber, before the heat is applied.

If the cooking chamber be 6 x 4 x 4½ inches, it will hold about three pounds of meat, which can be well cooked with a half inch wick in about one hour, the water being warm at the beginning. For such a vessel the pine walls need not be over 1½ inches thick.

In a cooking chamber 9 x 9 x 10 inches deep, surrounded by a half inch sheet of water in a pine box, of which the walls are 2 inches thick, ducks and grouse have been well cooked in about two hours, mutton in three hours, chickens or small turkeys in about four hours, with a one-inch wick, beginning with hot water. A longer time makes meat more tender.

In a cooking chamber 12 x 12 x 12 inches, surrounded by a half inch sheet of water, in a box of which the walls are 3 inches thick, 20 to 25 pounds of solid meat can be thoroughly cooked in six to eight hours; a longer time serves for very tough meat. An 18-pound ham or a 20-pound tough old turkey has been made very tender between 10 P. M. and 8 A. M.; 1 inch wick.

In this large cooker the heat of the lamp is more fully saved by the following arrangement: In place of the projecting metallic arm, from which much heat is radiated and lost, the arm connects with a metallic water jacket, surrounding the lamp chimney, which jacket is incased in wood. The same work may be done by jacketing the metal hood, *H H*, with fossil meal in a wooden case. The meal will protect the wood where it comes near the lamp.

Clear pine appears to be the best non-conductor. Experimenting might be tried with slabs made of wood pulp, which would be less liable to crack or shrink.

The fuel required is about one cent's worth of oil to 20 or 25 pounds of food. This quantity has sufficed for a very old 20-pound turkey, for 22 pounds round of beef, for 20 pounds shoulder of mutton, and for 18 pounds of ham. A very old gander, weighing 12 pounds, was cooked for 15 hours, at a cost of 1½ cents. The meat became so tender that it could not be carved. It was therefore minced.

Several different cooking vessels can be used in the same box. At one time 15 pounds of mutton bouillon, 7 pounds of beef, and 2½ pounds of oat meal with water were cooked a little too much in six and a half hours with one pint of oil.

These are the first crude results. A professed cook may attain much better ones, with greater economy of fuel. The lamp wick should be very carefully trimmed; and in order to avoid smell and smoke from the oil, the flame should not be put up to its full height until a few minutes after it is lighted. The food chamber being practically air tight, there is no loss by evaporation, and no odors of cooking are given off.

THE INFLUENCE OF LIGHT ON PLANT DEVELOPMENT.

A SERIES of researches have been carried out at Paris by M. Jules Lefèvre upon the influence of light upon the development of green plants, without carbonic acid, in an artificial soil charged with starch. These experiments were made in order to throw light upon a fundamental question, as to whether the work of synthesis which the green plant can carry on in starchy soil free from atmospheric carbonic acid is a general function of the vegetable protoplasm analogous to the work of nutrition of fungi, or whether it is a chlorophylian function, being produced in the light and ceasing in the dark. Experiment alone can decide this question. M. Lefèvre gives the results of his first researches upon the *Lepidium sativum* in a paper presented to the Académie des Sciences.

Two pots, *A* and *B*, were prepared with artificial earth, mineralized and watered with distilled boiled water. Both *A* and *B* have the earth charged with a starch mixture, and each is planted with forty seeds. After three weeks of proper development in the air, we weigh a lot of ten plants of pot *A* and the same from pot *B*, these plants having been previously dried for three days in the oven at 45 deg. Then the pots, each containing still thirty plants, are put under a bell-jar, in presence of baryta. But while *A* is left in strong diffused light, pot *B* is placed in the dark, by covering the bell-jar entirely with a thick black cover. The specimens *A* were found to develop, but on the contrary those of *B* pined away rapidly, refused to grow, and fell down after six or seven days' treatment. At this time we take the dry weight of ten plants from *A* and the same number from *B*. The weight of the ten plants taken at first from the pots is 0.03 gramme (0.46 grain), while the weight of ten plants from *B* (in the dark) is 0.026 gramme (0.40 grain) and from *A* (in the light) 0.055 gramme (0.85 grain). Thus we observe that the lot which is grown in the light has nearly doubled in weight, while the specimens in the dark have ceased to grow, and even have a slight loss. The same result is found with a lot of water-cresses which are well developed in the air.

In the dark they quickly fell down, without growth. Considering these results we are brought to conclude that without light, the synthesis operated by green plants free from carbonic acid in artificial starchy soil becomes impossible. This synthesis therefore appears as a chlorophylian function. Thus the chlorophylian assimilation may be a work of synthesis essentially, being accompanied, it is true, in ordinary growth with carbonic acid, by the double exchange of gases, that is, absorption of carbonic acid and disengagement of oxygen, which is characteristic of that assimilation.

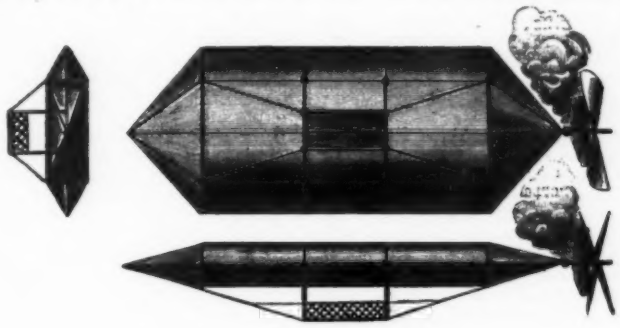


FIG. 1.

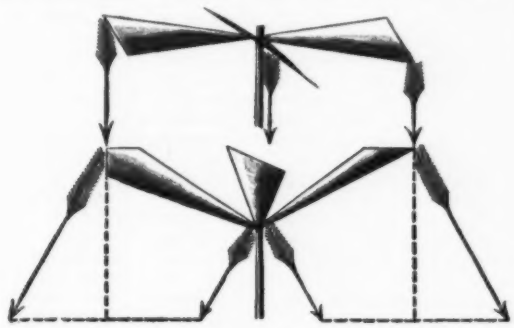


FIG. 2.

A PROPOSED SOLUTION OF THE PROBLEM OF FLIGHT.

By FRANZ PABISCH.

IT seems almost incredible that our highly developed technical skill has not produced an aerial vehicle that is at all practical. The reasons are, probably, that ignorant and unscientific experimenters have injured the cause, and that the method indicated to us by the birds, and used and improved by them through countless ages, has been neglected. We find in nature various modes of flying, but never the action of the screw-propeller, balloon, or kite, alone. Wing action combines all methods and such a combination and result should be the object of the aeronaut. Extreme lightness, stability, great power and automatic control are the fundamental conditions of success.

We shall see how well the proposed apparatus shown in Fig. 5 satisfies these conditions. First, however, some technical explanations are necessary.

For the navigation of the air two vehicles are available: the gas balloon, which is lighter than the lower stratum of air and floats upon it, and the flying machine, which must be kept in suspension by a motor. There is still a great difference of opinion among aeronauts concerning the respective merits of the two vehicles. The recognition of the impossibility of steering a spherical balloon has led to the adoption of cigar-shaped balloons, with which partial success has been attained. But perhaps the best result possible can be reached with the flat balloon of which three views are shown in Fig. 1. The silk-covered skeleton of steel tubes and wires has a broad bearing surface while its sharp edges offer little resistance to the air. The screw propeller, driven by a turbine or electric motor, should be mounted on a ball and socket joint and dirigible from the car, making rudders unnecessary. Still, however, a satisfactory solution of the problem is scarcely to be expected from balloons. Flying machines which depend wholly on wings or screw propellers promise much better results.

In the propeller (Fig. 2, above) two or more inclined blades turn swiftly about a vertical axis and create a conical base of support by means of the reaction of the air particles which they set in motion. Fig. 2 (below) shows a construction which has not yet been employed but which should be particularly efficient. The axes, or longest dimensions of the blades, are here inclined to the axis of rotation. This arrangement greatly increases the air resistance for a given diameter of the screw, providing a base of support in the form of an annular conical frustum whose cross section steadily increases as it is followed downward. The effect, therefore, is like that of the flapping of wings. Fig. 3 shows such a screw-propeller driven by a turbine aided by reaction. The steam, or the explosive mixture, enters the turbine through the hollow axis, and then passes through the hollow blades and escapes at their edges, thus adding the effect of a reaction engine to that of the turbine, and also partly preventing the formation of eddies. The power may be furnished by an explosive mixture or by steam from a Serpollet boiler. As the turbine may be subjected, without injury, to shocks and high temperatures and is the simplest, lightest, and most easily controlled of motors, it is the best one for this use, and, being made of sheet steel, it offers a stable base of attachment for the propeller. A single propeller, mounted on a ball and socket joint, would serve for support, propulsion, and steering, and the weight of the aeronaut would enable the center of gravity to be shifted, as occasion demanded.

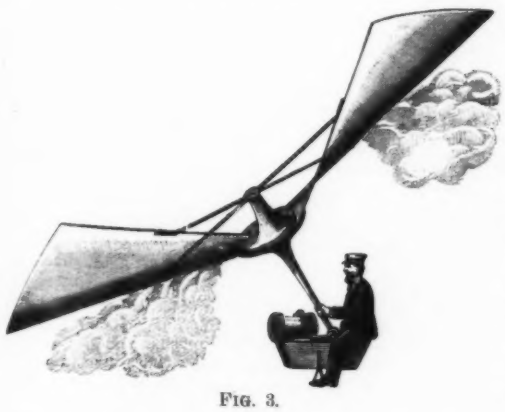


FIG. 3.

From the nature of the molecular movements of the air very favorable predictions may be made for flying machines with moving wings. At the commencement of the downward stroke the base of support is far greater than the area of the wing, and at the end of the stroke the air is compressed from both sides, as shown in Fig. 4. Unfortunately there are few experimental data concerning the action of wings, owing to the delicate mechanism involved and the effects of inertia brought into play in the changes of direction of heavy and swiftly moving wings. There can be no doubt, however, of the possibility of overcoming, by skillful steering, these difficulties, which have been overcome in the much heavier steam hammer.

Fig. 5 shows a winged flying machine which seems to satisfy the necessary conditions most fully. The long tubular axis of the apparatus carries the peculiar oscillating engine shown in section below. For the sake of lightness the cylinder and the two pistons are made of pressed nickel steel. The bent piston rods terminate in the arms which work the wings. The ends of these arms are connected by steel wires to the ends of the axis of the machine and the areas thus marked off are filled with adjustable "blinds" of very thin sheet steel. In the upstroke of the wing these blinds open to a certain angle, allowing air to pass through from above and driving the machine forward because of their inclination. In the downstroke they are closed and a lifting effect is obtained. Equilibrium and motion in a vertical plane are controlled automatically by the compressed air escaping from the pointed ends of the two large cylinders. Steering in a horizontal plane is effected by moving only one wing.

For the soul of the apparatus, the source of energy, alcohol vapor, which is easily condensed and also available as fuel, is particularly well adapted, though explosive mixtures may be employed.

The powerful downstroke of the wings is effected by means of the compressed air contained in the upper part of the cylinder and the vapor is used only for the upstroke. This secures economy in working. The boiler, of spiral steel tubes, is tested to fifty atmospheres and even in the case of a breakdown of the engine a sudden fall is prevented by the parachute action of the wings which are then directed downward. In landing and in violent gusts of wind safety is assured by the elastic construction, the vapor and compressed air.

In this machine propelling, steering, and gliding are combined in a simple manner, as in the flight of a bird, and its practical success is therefore almost assured. But of what use are the most beautiful schemes if they rest only on theory and calculation? Only practical experiments, carried on persistently in spite of repeated failures, will attain the goal. The cost of a few failures ought not to frighten the true-hearted pioneer, for no victory was ever yet won without sacrifice, and success in this case would be the most glorious triumph of the human mind. Only the most careful testing of sound theories and the proper utilization of the necessary means can secure the splendid results that are possible.—Translated from Stein der Weisen for the SCIENTIFIC AMERICAN SUPPLEMENT.

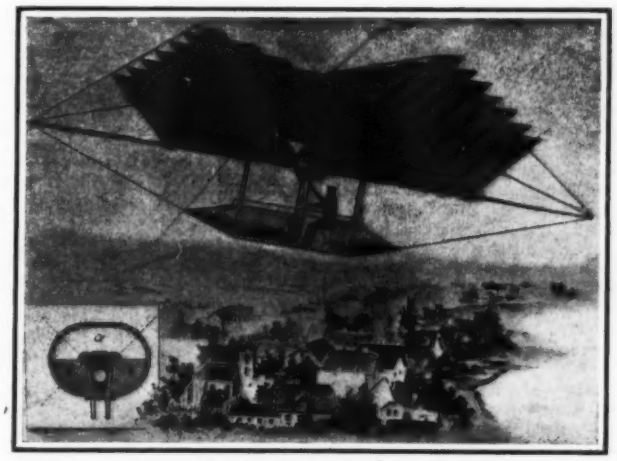


FIG. 5.

TRANSPORTATION ROUTES AND SYSTEMS OF THE WORLD.

"THE Transportation Routes and Systems of the World" is the title of a monograph just issued by the Department of Commerce and Labor through its Bureau of Statistics. It includes, in addition to statistical statements showing the development of transportation facilities on land and sea, a map by which is presented a bird's-eye view of the world's principal railway and steamship routes and the auxiliary relationship which one bears to the other.

Many maps showing vessel routes on the ocean have been published, also many maps showing the railways of the principal countries; but few if any attempts have been made to show even in outline in a single map the great transportation routes and systems of the entire world. The map, in conjunction with its accompanying tables, presents in outline a combination of the information regarding land and water routes usually found only in separate form in other publications. It does not enter upon any elaborate discussion of transportation routes, methods, or systems, but simply outlines in condensed form a few of the great highways of commerce by land and sea in combination. This seems especially appropriate at this time when the land and water transportation systems of the world are offering facilities by which the producer or merchant in the interior of one continent may ship his merchandise from his own door to that of the consignee in the far interior of another continent upon a through bill of lading, and therefore with a knowledge of the cost of transportation from his own establish-

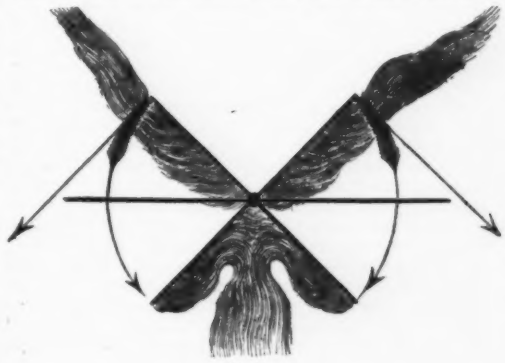


FIG. 4.

ment to that of the consignee and an assurance that the through freights shipped in this manner will pass promptly from the land vehicle to that of the ocean, and again from that of the ocean to that of the land.

The development of the systems of transportation which now place the producer in the interior of one continent in direct communication with the consumer in the interior of another continent is a product of a comparatively few years. Within the lifetime of men and women now living the world had not a single mile of railway, or a single steamship crossing the ocean. To-day the world has on land 550,000 miles of railway, and on the ocean 6 million net tons of sail-carrying power and 18 million net tons of steam-carrying power. At the beginning of the last century the sail-carrying power aggregated 4 million tons; steam-carrying power on the ocean did not exist, nor did railways on land exist. By the middle of the century sail-carrying power on the ocean was more than 11 million tons, the steam-carrying power on the ocean was less than 1 million tons, and the railways on land were but 24,000 miles. By 1880 sail power on the ocean had reached 14½ million tons, steam power about 6 million tons, and railways on land 225,000 miles. From that time forward steam power on the ocean so rapidly took the place of the sail that in 1905 sailing vessels on the ocean aggregated but 6 million tons carrying power, while steam vessels had an aggregate tonnage of 18½ million tons and railways an aggregate of 550,000 miles in length, of which 217,000 miles, or two-fifths of the total, are in the United States.

The development of railways has been, up to the present time, chiefly centered in the temperate zone, particularly Europe, and the United States, Mexico, and Canada in America, though Japan in the Orient and India in the tropics are now fairly well supplied with facilities for land transportation. The great trans-Siberian Railway is the sole transcontinental line between Europe and the Far East, while Australia's railways are confined chiefly to a line skirting the southern and eastern coast and a half dozen short lines tapping the interior. In Africa the British colonies at the south are fairly well equipped with railways, while the proposed Cape to Cairo transcontinental line is making substantial progress from Cairo, its terminus at the north, and Cape Town, its southern terminus, considerably more than one-half of the road being now completed and in operation. South America is still without any great railway system, her facilities being confined chiefly to eastern Brazil, northern Argentina, Chile, Paraguay, and Uruguay.

The United States leads the world both in the present mileage and the recent growth of its railways. Of the total railway mileage of the world, aggregating 534,000 miles for 1904, 211,074 miles were in the United States, 35,323 miles in European Russia, 32,967 miles in Germany, 28,102 miles in France, 26,950 miles in India, 24,120 miles in Austria-Hungary, 22,634 miles in the United Kingdom, 19,611 miles in Canada, 15,560 miles in Africa, 14,113 miles in Australia, 11,559 miles in Argentina, 10,356 miles in Mexico, 9,961 miles in Italy, 9,368 miles in Brazil, 7,697 miles in Sweden, 7,322 miles in Siberia, Manchuria, and other Asiatic possessions of Russia, 4,495 miles in Japan, and 1,176 miles in China. It was not until 1835 that the number of railways in operation in the United States first reached as much as 1,000 miles, being in that year 1,098 miles; by 1850 the total had grown to 9,021 miles; by 1860 to 30,626 miles; in 1865, 35,085 miles. In the decade from 1865 to 1875 the mileage more than doubled, the total for the last year named being 74,096; the total for 1885 was 128,320 miles, that for 1895 181,115 miles, for 1900 194,262 miles, and for 1905 217,328 miles, their aggregate cost being estimated by Poor's Manual for 1905 at the enormous sum of 11 2-3 billions of dollars, out of an aggregate cost of 37 billions for the entire world.

The total net tonnage of the steam and sailing vessels of the world, including only vessels of over 100 tons each, is stated by Lloyd's Register at about 6 million tons of sail and 18½ million tons of steam. Of this total of 24½ million tons, 11 million tons, or nearly one-half, is credited to the United Kingdom and her colonies, 3¼ millions to the United States, 1 1-3 millions to Norway, 1 1-5 millions to France, and about one-half million tons each to Russia, Sweden, Spain, Japan, and the Netherlands, in the order named.

In sharp contrast with the rapid growth achieved by American railways is the slow development of the merchant marine of the United States. The tonnage of vessels engaged in the foreign trade of the United States was, in 1855, 2,348,358 tons; in 1875, 1,515,598 tons; in 1895, 822,347 tons; and in 1905, 943,750 tons. The tonnage of vessels engaged in the coastwise trade of the United States was 2,543,255 tons in 1855, 3,219,698 tons in 1875, 3,728,714 tons in 1895, and 5,441,688 tons in 1905; while the total tonnage of the merchant marine of the United States, including all vessels whether engaged in the foreign trade, the coastwise trade, or the whale, cod, and mackerel fisheries, has only grown from 5,212,001 tons in 1855 to 6,456,543 tons in 1905.

Freight rates are shown to have decreased both on land and sea. The average rate per bushel of wheat from Chicago to New York has decreased as follows: By lake and canal, from 26.6 cents in 1865 to 4.7 cents in 1905; by lake and rail, from 29 cents in 1868, the earliest available date, to 5 cents in 1905; by railway only, from 46 cents in 1866 to 11 cents in 1905. For the same commodity the rate between New York and Liverpool, while subject to wide fluctuations, has shown a general decline especially in more recent years. In 1873 the rate per bushel of wheat from New York to Liverpool was 10 9-16 cents; in 1875, 8 7-16 cents; in 1885, 3 3-16 cents; in 1895, 2 9-16 cents; and in 1905, 1¼ cents.

During the latest year for which statistics are available, the railways of the United States carried 719,654,951 passengers and transported 1,300 million tons of freight, against 351,427,688 passengers carried and 437 million tons of freight transported in 1885.

The close connection between adequate transportation facilities and commerce is illustrated by the fact that in 1800, when there were no railroads or steamships and but 4 million tons of sail carrying power on sea, the world's commerce was but 1½ billions of dollars, while at the present time, aided by nearly 550,000 miles of railway and the ocean steam and sail tonnage above described, its international commerce approximates 22½ billions of dollars. Thus, under the newly created transportation systems of the last century, which have developed the interior of continents and made merchantable many commodities which formerly would not bear the cost of transportation, the internal commerce of the world is to-day about fifteen times as much as at the beginning of last century, while the world's population is but two and one-half times as great as at that time, the commerce of the world's population, as a whole, having thus grown from less than $2.50 per capita in 1800 to nearly $14 per capita at the present time.

INSECTS AS CARRIERS OF DISEASE.*

THE last few years are marked in the annals of medicine by a great increase in our knowledge of certain parasitic diseases, and, above all, in our knowledge of the agency by which the parasites causing the diseases are conveyed.

Chief among these agencies, in carrying the disease-causing organisms from infected to uninfected animals, are insects, and, among the insects, above all, flies. The common house-fly (*Musca domestica*) can carry about with it the bacillus of anthrax. Flies, ants, and other even more objectionable insects are not only capable of disseminating the plague bacillus from man to man, and possibly from rat to man, but they themselves fall victims to the disease, and perish in great numbers. They are active agents in the spread of cholera, and the history of the Boer war definitely shows that flies play a large part in carrying the bacilli of enteric fever from sources of infection to the food of man, thus spreading the disease.

The diseases already mentioned are caused by bacteria. But flies also play a part in the conveyance of a large number of organisms which are not bacteria, but which, nevertheless, cause disease.

In considering the part played by flies in disseminating disease not caused by bacteria, we can neglect all but a very few families, those flies which suck blood having alone any interest in this connection.

From the point of view of the physician, by far the most important of these families is the Culicidæ, with more than 300 described species and five sub-families, of which two, the Culicina and the Anophelina, interest us in relation to disease. The gnats or mosquitoes are among the most graceful and most beautiful insects that we know; but they have been judged by their works and undoubtedly are unpopular, and we shall see this unpopularity is well deserved. Gnats belong both to the genus Culex and to the genus Anopheles. The genus Culex, from which the order takes its name, includes not only our commonest gnat, often seen in swarms on summer evenings, but some 130 other species. Members of this genus convey from man to man the *Filaria nocturna*, one of the causes of the widely-spread disease filariasis. In patients suffering from this disease, minute embryonic round-worms swarm in the blood-vessels of the skin during the hours of darkness. Between six and seven in the evening they begin to appear in the superficial blood-vessels, and they increase in number until midnight, when they may occur in such numbers that five or six hundred may be counted in a single drop of blood. After midnight, the swarms begin to lessen, and, by breakfast time, about eight or nine in the morning, except for a few strayed revelers, they have disappeared from the superficial circulations and are hidden away in the larger blood-vessels and in the lungs.

In spite of their incredible number (some authorities place it at thirty to forty millions in one man), these minute larval organisms, shaped something like a needle pointed at each end, seem to cause little harm. It might be thought that they would traverse the walls of the blood-vessels, and cause trouble in the surrounding tissues; but this is prevented by a curious device. It is well known that, like insects, round-worms from time to time cast their skins, and the young larvæ in the blood cast theirs, but do not escape from the inside of this winding-sheet; and thus, though they actively wriggle and coil and uncoil their bodies, their progress is as small, and their struggles as little effective, as are those of a man in a strait-waistcoat.

One reason of the normal appearance of the creatures in the blood at night is undoubtedly connected with the habits of its second host, the gnat or mosquito. Two species are accused of carrying the Filaria from man to man—*Culex fatigans* and *Anopheles nigerrimus*. Sucked up with the blood, the round-worms pass into the stomach of the insect. Here they appear to become violently excited, and rush from one end to the other of their enveloping sheath, until they succeed in breaking through it. When free, they pierce the walls of the stomach of the mosquito, and come to rest in the great thoracic muscles. Here the Filarias rest for some two or three weeks, growing considerably and developing a mouth and an alimentary canal; thence, when they are sufficiently developed, they make their way to the proboscis of the mosquito. Here they lie in couples. Exactly how they effect their exit from the mosquito and their entrance into man has not yet been accurately observed; but presumably it is during the process of biting. Once inside man, they work their way to the lymphatics, and very soon the female begins to pour into the lymph a stream of young embryos, which reach the blood-vessels through the thoracic duct. It is, however, the adults which are the source of all the trouble. They are of considerable size, three or four inches in length; and their presence, by blocking the channels of the lymphatics, gives rise to a wide range of disease, of which elephantiasis is the most pronounced form.

We now pass to the second of the diseases carried by gnats, that of malaria.

The parasite which causes malaria is a much more lowly organized animal than the Filaria. It is named Hæmamœba, and it too is conveyed by an insect, and, so far as we know, by one genus of mosquito only, the Anopheles. Hence from the point of view of malaria it is important to know whether a district is infected with Culex or Anopheles. The former is rather humpbacked and keeps its body parallel with the surface it is biting, and its larva hangs at an angle below the surface of the water by means of a respiratory tube. Anopheles, on the other hand, carries its body at a sharp angle with the surface upon which it rests, and its larva lies flat below the surface-film and parallel with it. The malarial parasite lives in the blood-cells of man, but at a certain period it breaks up into spores which escape into the fluid of the blood, and it is at this moment that the sufferer feels the access of fever. Their presence and growth within the blood-cells result in the destruction of the latter, a very serious thing to the patient if the organisms be at all numerous. If the spores be sucked up by an Anopheles, they undergo a complex change, and ultimately reproduce an incredible number of minute spores or sporozoites, each capable of infecting man again if it can but win entrance into his body.

In normal circumstances, for each Filaria larva which enters a mosquito one Filaria issues forth, longer, it is true, and more highly developed, but not much changed. The malaria parasite undergoes, in its passage through the body of the Anopheles, many and varied phases of its life-history. As the Frenchman said of the pork, which goes into one end of the machine in the Chicago meat-factories as live pig, and comes out at the other in the form of sausages, "*Il est diablement changé en route.*"

Whoever has watched under a lens the process of "biting," as carried on by a mosquito, must have observed the fleshy proboscis (labium) terminating in a couple of lobes. The labium is grooved like a gutter, and in the groove lie five piercing stylets, and a second groove or labrum. It is along this labrum that the blood is sucked. Between the paired lobes of the labium, and guided by them (as a billiard cue may be guided by two fingers), a bundle of five extremely fine stylets sinks slowly through the epidermis, cutting into the skin as easily as a knife into a soft cheese. Four of these stylets are toothed, but the single median one is shaped like a two-edged sword. Along its center, where it is thickest, runs an extremely minute groove, only visible under a high power of the microscope. Down this groove flows the saliva, charged with the spores or germs of the malaria-causing parasite. Through this minute groove has flowed the fluid which, it is no exaggeration to say, has changed the face of continents and profoundly affected the fate of nations.

It is an interesting fact that, among the Culicidæ, it is the female alone that bites, and she is undoubtedly greedy. If undisturbed, she simply gorges herself until every joint of her chitinous armor is stretched to the cracking point. She never ceases sucking. The great majority of individuals, however, can never taste blood, and subsist mainly on vegetable juices.

Anopheles is often conveyed great distances by the wind, or in railway trains or ships; but of itself it does not fly far; about five or six hundred yards—some authorities place it much lower—is its limit. Both Anopheles and Culex lay their eggs, as is well known, in standing water, and here three out of the four stages in their life-history—the egg, the larva, and the pupa—are passed through. The larva and the pupa hang onto the surface-film of the water by means of certain suspensory hairs, and by their breathing apparatus. Anything which prevents the breathing tubes reaching the air insures the death of the larva and pupa. Hence the use of paraffin on the pools or breeding places. It, or any other oily fluid, spreads as a thin layer over the surface of the pools and puddles, and clogs the respiratory pores, and the larvæ or pupæ soon die of suffocation.

Thus a considerable degree of success has attended the efforts of the sanitary authorities, largely at the instigation of Major Ross, all over the world, to diminish the mosquito plague. It is, of course, equally important to try and destroy the parasite in man by means of quinine. This is, however, a matter of very great difficulty. In Africa and in the East nearly all native children are infected with malaria, though they suffer little, and gradually acquire a high degree of immunity. Still, they are always a source of infection; and Europeans living in malarious districts should always place their dwellings to the windward of the native settlements.

* From an address delivered before the British Association at Pretoria, by A. E. Shipley, F.R.S.

Another little gnat, *Stegomyia fasciata*, closely allied to Culex, with which, until recently, it was placed, is the cause of the spread of that most fatal of epidemic diseases, the yellow fever. Like the Culex, but unlike the Anopheles, Stegomyia has a humpbacked outline, and its larva has a long respiratory tube at an angle to its body, from which it hangs suspended from the surface-film of its watery home. It is a very widely distributed creature; it girdles the earth between the tropics, and is said to live well on shipboard. It breeds in almost any standing fresh water, provided it be not brackish. The female is said to be most active during the warmer hours of the day, from noon until three or so, and in some of the West Indies it is known as the "day-mosquito."

The organism which causes yellow fever has yet to be found. It seems that it is not a bacterium, and that it lives in the blood of man. It evidently passes through a definite series of changes in the mosquito, for freshly infected mosquitoes do not at once convey the disease. After biting an infected person it takes twelve days for the unknown organism to develop in the Stegomyia, before it is ready for a change of host. The mosquitoes are then capable of inoculating man with the disease for nearly two months. The period during which a man may infect the mosquito, should it bite him, is far shorter, and extends only over the first three days of the illness.

Very careful search has hitherto failed to reveal the presence of the parasite of yellow fever. By its works alone can it be judged. It seems that, like the germ of rinderpest and of foot-and-mouth disease, it is ultramicroscopic; and our highest lenses fail to resolve it.

King Solomon sent to Tarshish for gold and silver, ivory, and apes and peacocks, and, at the present day, people mostly go to Africa for gold, diamonds, ivory, and game. These are the baits that draw them in. Of the great obstacles, however, which have for generations succeeded in keeping that great continent, except at the fringes, comparatively free from immigrants, three, and these by no means the least important, are insignificant members of the order Diptera. We have considered the case of Culex and Anopheles; the third fly we have now to do with is the tsetse fly (Glossina), which communicates fatal diseases to man and to cattle and domesticated animals of all kinds.

The members of the genus Glossina are unattractive insects, a little larger than our common house-fly, with a sober brownish or brownish-gray coloration. When at rest the two wings are completely superimposed, like the blades of a shut pair of scissors; and this feature readily serves to distinguish the genus from that of all other blood-sucking flies, and is of great use in discriminating between the tsetse and the somewhat nearly allied Stomoxys and Hæmatopota.

The tsetse flies rapidly and directly to the object it seeks, and must have a keen sense of smell, or sight, or both, making straight for its prey, and being most persistent in its attacks. The buzzing which it produces when flying is peculiar, and easily recognized again when once heard. After feeding, the fly emits a higher note, a fact recalling the observation of Dr. Nuttall and the present writer, on the note of Anopheles, in which animal we observed that "the larger the meal the higher the note." The tsetse does not settle lightly and imperceptibly on the sufferer as the Culicidæ do, nor does it alight slowly and circumspectly after the manner of the horse-flies, but it comes down with a bump, square on its legs. Like the mosquito, the tsetse is greedy, and sucks voraciously. The abdomen becomes almost spherical, and of a crimson red. Unlike so many of the blood-sucking Diptera, in which the habit is confined to the females, both sexes of Glossina attack warm-blooded creatures.

The fly always seems to choose a very inaccessible portion of the body to operate on, between the shoulders in man, or on the back and belly in cattle and horses, even inside the nostrils in the latter, or on the forehead in dogs. According to Lieut.-Col. D. Bruce, R.A.M.C., to whom we owe so much of our knowledge of this fly and its evil work, the female does not lay eggs, but is viviparous, and produces a large, active, yellow larva, which immediately crawls away to some secluded crevice, and straightway turns into a hard, black pupa, from which the imago emerges in some six weeks. Thus two stages, the egg and the larva, both peculiarly liable to destruction, are practically skipped in the tsetse, at any rate in some species.

The genera of the Culicidæ which we have considered are found practically all over the world, but the genus Glossina is fortunately confined to Africa. From the admirable map of the geographical distribution of the fly compiled by Mr. Austen, we gather that its northern limit corresponds with a line drawn from the Gambia, through Lake Chad to Somaliland, somewhere about the thirteenth parallel of north latitude. Its southern limit is about on a level with the northern limit of Zululand. The tsetse, of course, is not found everywhere within this area; and, though it has probably escaped observation in many districts, it seems clear that it is very sporadically distributed.

Even where the tsetse is found, it is not uniformly distributed, but occurs in certain localities only. These form the much dreaded "fly-belts." The normal prey of the fly is undoubtedly the big game of Africa. But they are not the only factor in its distribution. The nature of the land also plays a part. There are the usual discrepancies in the accounts of travelers, especially of African travelers, as to the exact localities the Glossina affects; but most writers agree that the tsetse is not found in the open veldt. It must have cover. Warm, moist, steamy hollows, containing water and clothed with forest growth, are the haunts chosen.

The tsetse fly belongs to the family Muscidæ, the true flies, a very large family, which also includes our house-fly, blue-bottle fly, etc. These flies, unlike Anopheles and Culex, are day-flies, and begin to disappear at or about sunset.

The practical disappearance as the temperature drops has enabled the South African traveler to traverse the fly-belts with impunity during the cooler hours of the night. At nightfall the tsetse seems to retire to rest among the shrubs and undergrowth; but, if the weather be warm, it may sit up late; and some experienced travelers refrain from entering a fly-belt, especially on a summer's night, until the temperature has considerably fallen.

The sickness and death of the cattle bitten by the tsetse were formerly attributed to some specific poison secreted by the fly, and injected during the process of biting. It is now, largely owing to the researches of Col. Bruce, known to be due to the inoculation of the beasts with a minute parasitic organism conveyed from host to host by the fly. The disease is known as "nagana," and the organism that causes it is a species of Trypanosoma, a flagellate protozoon or unicellular organism, which moves by means of the lashing of a minute, whip-like process. Since Bruce's researches, a number of Trypanosomas have been found causing disease in various parts of the world; thus *T. evansii* causes the surra disease of cattle, horses, and camels in India; *T. equinum* produces the "mal de caderas" of the horse ranches of South America; and *T. equiperdum* is responsible for the North African disease called by the French the dourine; *T. theileri* causes the gall-sickness, and there are others. The particular species of Trypanosoma which causes nagana is *Trypanosoma brucei*, and it does not attack man; goats and donkeys seem also immune; but, with these exceptions, all domesticated animals suffer, and in a great percentage of cases the disease terminates in death. Just as the native children in Africa form the source of the supply of the malarial parasite without appearing to suffer much, so do the big game of the country abound in Trypanosoma without appearing to be any the worse. They are in Lankester's phrase "tolerant" of the parasite, and a harmony between them and the parasite has been established, so that both live together without hurting one another. It is from the big game that the disease has spread. In their bodies the harmful effect of the parasite has, through countless generations, become attenuated; but it leaps into full activity again as soon as the Trypanosoma wins its way into the body of any introduced cattle, horse, or domesticated animal.

The report of Col. Bruce, which has just been issued, shows that the sleeping sickness which devastates Central Africa, from the west coast to the east, is also conveyed by a species of tsetse fly. Writing more than a hundred years ago of Sierra Leone, Winterbottom mentions the disease. "The Africans," he says, "are very subject to a species of lethargy which they are very much afraid of, as it proves fatal in every instance." Early last century it was recorded in Brazil and the West Indies; and Lankester has suggested that the deaths which our slave-owning ancestors used to attribute to a severe form of homesickness, or even to a broken heart, were in reality caused by sleeping sickness. In one year the deaths in the region of Busoga reached a total of 20,000; and it is calculated that although the disease was only noticed in Uganda for the first time in 1901, by the middle of 1904 100,000 people had been killed by it. The disease is caused by the presence of a second species of Trypanosoma in the blood and in the cerebro-spinal fluid. The existence of this parasite has now been proved in all the cases recently investigated. Apparently the Trypanosoma can live in the blood without doing much harm, and only when it reaches the cerebro-spinal canal does it set up the sleeping-sickness. It is also found in great numbers in the lymphatic glands, especially those of the neck, which in patients infected by the parasite are usually swollen and tender. From the similarity of the parasite to that causing the cattle disease of South Africa, the idea at once arose that the Trypanosoma was conveyed from man to man by a biting insect. Along the lake shores a species of tsetse (*G. palpalis*) abounds; and it was noticed that if the fly, having fed off a sleeping-sickness patient, bit a monkey, the monkey became infected. Further, flies which were captured in a sleeping-sickness district were also capable of conveying the disease to healthy monkeys. The proof that sleeping sickness is due to a Trypanosoma known as *T. gambiense* present in the cerebro-spinal fluid of the patient, due to the brilliant research of Col. Bruce and his colleagues, Capt. Grieg and Dr. Nabarro, and that it is conveyed from man to man by *Glossina palpalis*, seems now complete.

Finally, we come to a last class of diseases which is of the utmost interest to the agriculturist and settler, and yet at present is but little understood. These diseases are caused by various species of a protozoon named Piroplasma, and the diseases may collectively be spoken of as piroplasmosis. When they are present in cattle they are spoken of in various parts of the world as Texas fever, tick-fever, blackwater, and redwater. Heartwater in sheep is a form of piroplasmosis. Horses also suffer, and the malignant jaundice or bilious fever which makes it impossible to keep dogs in certain parts of this country is also caused by a Piroplasma. Finally, under the name of Rocky Mountain fever, spotted- or tick-fever, the disease attacks man throughout the west half of the United States.

The organisms which cause the disease live for the most part in the red blood corpuscles, but they are sometimes to be found in the plasma or liquid of the blood. Unfortunately we know comparatively little about the life-history of the Piroplasma or of the various stages it passes through, but we do know how it is transmitted from animal to animal and from man to man.

We have seen that the carrier or "go-between" in the case of the malaria is the mosquito, and in the case of the sleeping sickness is the tsetse fly. Piroplasma, however, is not conveyed from host to host by any insect, but by mites or ticks, members of the large group of Acarines, which include besides the mites the spiders, scorpions, harvestmen, and many others.

The ticks differ from the insect bearers of disease, inasmuch as the tick that attacks an ox or a dog does not itself convey the disease, but it lays eggs—for I regret to say here, as with the Anopheles, it is the female only that bites—and from these eggs arises the generation which is infective, and which is capable of spreading the disease. The tick which conveys the Piroplasma from dog to dog is called *Hæmophysalis leachi*. The brilliant researches of Mr. Lounsbury have shown that even the young are not immediately capable of giving rise to the disease. The female tick gorges herself with blood, drops to the ground, and begins laying eggs. From these eggs small six-legged larvæ emerge. These larvæ, if they get a chance, attach themselves to a dog, gorge themselves, and after a couple of days fall off. If their mother was infected they nevertheless do not convey the parasite. After lying for a time upon the ground the larval tick casts its skin and becomes a nymph, a stage roughly corresponding with chrysalis of a butterfly. This nymph, if it has luck, again attaches itself to the dog and has a meal, but it also fails to infect the dog. After a varying time it also drops to the ground, undergoes a metamorphosis, and gives rise to the eight-legged adult tick. Here at last we reach the infective stage; the adult tick is alone capable of giving the disease to the animal upon which she feeds, and then only when she is descended from a tick which has bitten an infested host. Think what a life-history this parasite has! Living in the blood-corpuscles of a dog, sucked up by an adult tick, passed through her body until it reaches an egg, laid with that egg, being present while the egg segments and slowly develops into the larva; living quiescent during the larval stage and the nymph stage, surviving the metamorphosis, and only leaping into activity when the adult stage is reached. This most remarkable story probably indicates that the Piroplasma undergoes a series of changes comparable to those of the malaria organism when it is inside the mosquito; what these stages are we do not at present know, but Dr. Nuttall and Mr. Smedley at Cambridge, and many other observers elsewhere, are at work on the problem, and soon we shall have more light.

With regard to bovine piroplasmosis, Koch and others have distinguished redwater fever, which is conveyed by *Rhipicephalus annulatus*, and in Europe probably by *Ixodes reduvius* from the Rhodesian fever which is conveyed by *Rhipicephalus appendiculatus*, and I regret to say by a species dedicated to myself, *Rhipicephalus shipleyi*.*

The heartwater disease of sheep and goats is similarly conveyed by *Amblyomma hebraeum*, the Bont tick, and many farmers accuse *Ixodes pilosus* of causing the well-known paralysis from which sheep suffer in the early autumn; and there are many others, diseases such as the chicken disease of Brazil, which is so fatal to poultry yards, and which is conveyed by the *Argas persicus*.

Correspondence.

SOME REMARKABLE TRACK LAYING.

To the Editor of the SCIENTIFIC AMERICAN:

I notice in your issue of the SCIENTIFIC AMERICAN SUPPLEMENT, *re* opening of bridge over Victoria Falls, that part of the line, 5½ miles, was completed in one day; and that was a *world's record*.

Now, take the line which unites Sacramento with Ogden, 743 miles, commenced in 1863 and finished in 1869. About 50 miles west of Ogden the remarkable engineering feat of laying 10 miles of railway in one day was performed. It was thus accomplished: When the wagon loaded with the rails arrived at the end of the track, the two outer rails were seized, hauled forward of the car, and laid upon the sleepers by four men who attended to this duty only. The wagon was pushed forward over these rails, and the process of putting down the rails was repeated, while behind the wagon came a little army of men who drove in the spikes and screwed on the fishplates, and lastly, a large number of Chinese workmen, with pickaxes and spades, who ballasted the line. The average rate at which these operations proceeded was about 240 feet of track in 77½ seconds, and in these 10 miles of railway there were 2,585,000 crossties, 3,520 iron rails, 55,000 spikes, 7,040 fishplates, and 14,080 bolts with screws—the whole weighing 4,362,000 pounds. Four thousand men and hundreds of wagons were required, but in the 10 miles all the rails were laid by the same eight men, each of whom is said to have walked that day 10 miles and lifted 1,000 tons of iron rails. Eight miles of this track was laid in six hours, which was the victory achieved by these stalwart navvies before dinner. So I think this will beat your Victoria Falls affair all to bits every time. Give your own country praise and honor when it is due. This was done over fifty years ago. What would they do now? Why, they could double it, or do it before breakfast.

THOMAS SMITH.

Chermside P. O., Queensland, December 8, 1905.

* This happily turns out to be a synonym.

OYSTER CULTURE IN JAPAN.

SEEING the skillful manner in which the Japanese put to profit all the products of the sea and convert the least bit of waste material into manure for the soil, it is needless to say that oyster raising would necessarily have been practised provided this edible bivalve were contained in their seas. Now, as a matter of fact, species of this mollusk are found on the Japanese coast and have naturally become an object of culture. The methods employed in this work have lately been described by Prof. Bashford Dean, of Columbia University, in an elaborate paper from which we glean the following information. Two species of oysters are found in the Japanese waters, both of which are consumed in varying quantities. One of these, a small and even dwarf one, *Ostrea cucullata*, that is met with in abundance in shoal waters, forms compact layers upon rocks which are exposed at low tide. It is about as wide as the finger nail, does not exceed two inches in length, and has a most exquisite flavor. Another form of this oyster, the one that is cultivated and is of the size of the English species, has a wide shell, which is nacreous internally and imbricated externally, and recalls the European oyster. It abounds in the Interior Sea, in the small bays of the northwest coast of the great Japanese island, and to some extent at Yeddo. Its fry is met with in shallow and somewhat fresh water. The best, of marketable size, are found at a depth of one or two fathoms below the limit of low tide, and at a depth of eight fathoms are no longer met with. The second species is the *Ostrea gigas*, which, with the shell, often weighs five pounds. It is met with at a depth of ten fathoms and in relatively slight abundance. We shall occupy ourselves with the *Ostrea cucullata* solely.

The oyster cultural region *par excellence* of Japan is the Interior Sea, which may be regarded as a huge natural reservoir of fishes and shell-fishes. It is almost a marine lake, and one in which the animals are not only sheltered, but have the advantage of living in properly renewed water. To the east, this sea opens upon the ocean through the straits of Naverto and Izuminada, and to the west upon the sea of Japan through the strait of Shimonoseki, while the Bungo canal establishes, at the south, another communication with the Pacific. It is in that part of this sea in which islands abound that are found united the conditions favorable for the culture of shell-fish in general. The bottom is of sand or gravel, and the change of level due to tides varies between 10 and 15 feet, both essentially favorable conditions for oyster culture. The true seat of this industry is, on the one hand, at Okayama, and, on the other, in the vicinity of Hiroshima—the establishments of Nihojima, Kaida, and Kusatsu meriting particular mention. These centers, however, differ somewhat in consequence of local conditions, in that the first is devoted especially to the production of the fry in water freshened by the influx of a river, and the second to the production of the young and to the rearing of them, while the third presents the best situation for growing the larger oysters. It is at Kaida that the methods are simplest, and at Kusatsu the most complicated, while the processes of culture at Nihojima are surpassed at but a few points in Europe.

At Kaida, that is to say, in the bay that bears this name, great flat spaces are uncovered at low water; but there are too few places where the oysters can remain constantly under water at all times, and it is for that reason that the mollusks grow but slightly therein after their second year. Here, at low tide, is perceived a series of contiguous parks in which bamboos planted in the ground give the whole the aspect of vineyards

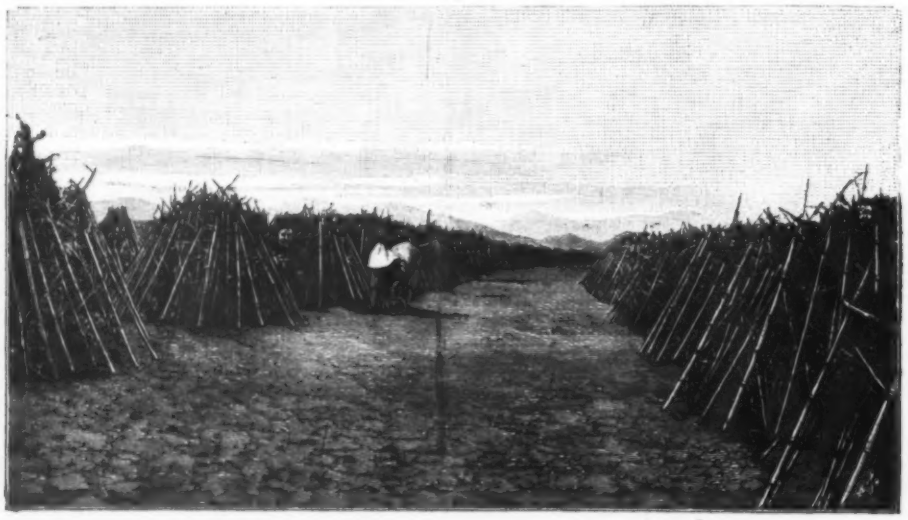


FIG. 2.—A JAPANESE OYSTER PARK AT LOW TIDE.

(Figs. 1 and 2). It was impossible to do otherwise than employ the bamboo here since it has the advantage of lasting for three or four years in sea water. The part used is the stalk or "shibi," along with its branchlets and leaves so as to considerably increase the surface offered to the young oysters during the process of growth. These bamboos can be easily driven into the ground or removed therefrom. They can be obtained anywhere at a very low price. They are put down every year at about the middle of April upon the grants accorded by the government. A sort of fence is at first staked out according to the boundaries of the park, and then fences parallel with them, and at right angles with the long axis of the park, are formed in such a way as to leave a sort of alley to permit of easily moving about. From this central alley start lateral ones about six feet in width. The fences are about the height of a man's breast, and are generally formed, except at the circumference of the park, of two rows of bamboos inclined toward each other, one

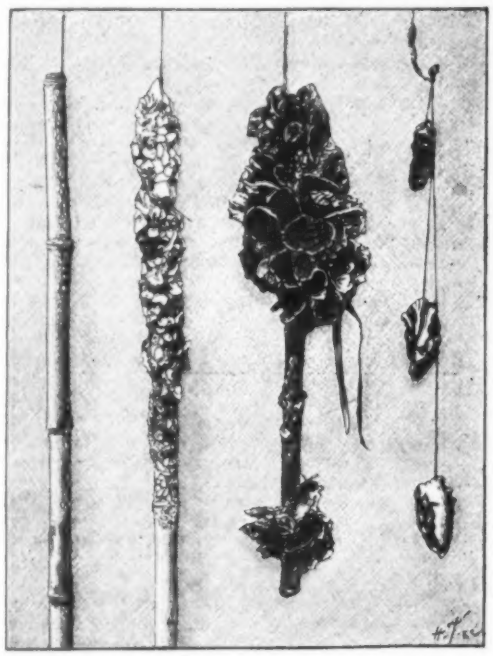


FIG. 1.—BAMBOOS CARRYING OYSTERS OF DIFFERENT AGES, AND ALSO MARKETABLE OYSTERS.

being of the series of collectors serving for oysters one year old, and the others for oysters two years old. The branchlets interlace and thus give strength to the double fence. At the end of the second year all that has to be done is to remove the marketable oysters by means of a special tool. They are then gathered into a pile by means of a rake and afterward put into baskets and carried to the mouth of a river in order to "make them drink," as the saying is. This cleans and distends them, and renders them fit for sale. At Kusatsu, the oysters are cultivated at greater depths, because it has been found that they then develop at the end of their second year. It is for that reason that the parks, or "farms" as they are also called, are here divided into three kinds—one of slight depth for the fry, one for the beginning of the rearing, and one for the end of the same. In this way the grants become elongated into relatively narrow strips with their long axis at right angles with the shore line, a single grant offering all the depths of water desired. In the zone of slight depth, we find again the bamboo collector or "shibi" arranged in somewhat the same manner, in lines parallel with the shore and separated by a space of four feet. Sometimes, however, the bamboo rods are stuck into the ground after being deprived of their branches, and in this case are placed much closer together. At any event, the rods employed here must be stronger, because the currents are more violent, and it is for this reason that it is often found advantageous to strip off the leaves, which would offer too great a resistance to the water in motion. In most cases, seven rods are united in order to form a sort of convergent or divergent bundle that shall present greater strength. When the currents are particularly to be feared an interval of from 8 to 10 feet is left between the rows of bundles. The center of the bundle or "toya" is made of a "shibi" that is planted in the ground with all the fry that it carries. Moreover, quite complicated arrangements of bundles are frequently adopted. Every year, toward the period of spawning, at the end of August or beginning of September, the bundles are taken apart and the bamboo rods that seem to be no longer strong enough are set aside, and the oysters that appear to have too slight a hold on the wood are detached and carried to the grounds called "ike-ba," where there is a greater depth of water. These have a bottom of very clean gravel which is entirely exposed only at very low tides. The oysters are spread in very carefully maintained beds on which they are kept until they reach their second year. As they must be kept separate from one another, a rake is passed over them every fortnight so as to isolate them and remove foreign bodies. It is asserted, even, that this gives the shells a more regular form. The oysters that have not been submitted to this raking during their growth break quite easily during carriage to the market, and the juice has a tendency to escape, to the great detriment of the animal. At Kusatsu the culture is generally completed by a passage to the maturing grounds or "miire-ba," to which are carried the largest two-year-old oysters. The maturation takes place in zones of very great depth, sometimes of fifty feet, evidently at high tide, however. The bivalves are protected by a sort of low fence forming wings and preventing the deposit of mud. The maturation causes the oysters to grow, fatten, and become white. After they have reached their third year, they are shipped to the market.

We shall terminate this excursion to the domain of oyster culture by a visit to the parks of Nihojima, where there are grounds appropriated and reserved for the production of fry while the first part of the culture is proceeding at special points of the shore, and the maturation of the oysters is taking place at other parts of the coast. At these different parks the processes employed and the installations adopted resemble to a considerable extent those that we have described in the case of Kusatsu. The fry is collected at a depth not exceeding one foot at low tide, and in water of which the specific density does not exceed 1.017; and three months after the fry has become deposited upon the collector; it is removed to a place which is better adapted for the culture of the young. The operation must be performed with all sorts of precautions that the fry shall not be injured. It is necessary to prevent shocks, friction, dryness and effects of the sun, changes of temperature and storms. The young thus transplanted remain in place for from one to two years and a half. The culture is finished at the maturing and fattening grounds, as we have already stated.

Let us add, in conclusion, that all the grounds fitted for oyster culture belong to the State and cannot be sold or sub-let by the grantees. The grants, however, are sold at auction and are capable of being renewed indefinitely.—Translated from La Nature for the SCIENTIFIC AMERICAN SUPPLEMENT.

NEW USES OF PEAT AND FOREST PRODUCTS IN GERMANY.

By WILLIAM MAYNER.

IN a series of luminous articles contributed by Prof. Wislicenus, of Tharandt, the latest achievements of German scientists in the domain of peat utilization and the chemical use of forest products are elaborately described.

Wood as a fuel has long been superseded by coal, but in its turn, wood and its by-products have successfully competed with iron, wire, cement, and linoleum; and so-called xylolith, or "stonewood," a product of sawdust with the new magnesia cement, is now largely used as a substitute for wooden boards and beams. Peat, on the other hand, is competing with wood as a fuel, and serves as raw material for textile manufactures, paper, cardboard, etc. Lately, artificial timber and boards have been made of peat which are unequaled, on account of their fire-proof qualities.

With the help of natural water power and by the application of improved methods, on the lines of "Siemens generator gas" making, peat has been utilized for producing "peat gas."

The latest form of using peat as a fuel is by a process invented by Dr. Count von Schwerin, the patents on which have been acquired by the Höchster Farbwerke in Höchst a/M., the product being called "osmon." The greatest difficulty for using peat has hitherto been the peculiar tenacity with which peat retains its contents of water, amounting to 85 and 90 per cent. This quantity is reduced through the osmon apparatus, by applying an electric current of 10 to 12 kilowatts, to one cubic meter of raw peat, to 65 or 70 per cent of water, and the remaining quantity of liquid is easily reduced to 15 per cent by air drying, the product being a substance very similar to brown coal. It can, the same as coals, be broken up in lumps, thus avoiding the great drawback in briquettes, which are very apt to fall to pieces suddenly and to consume rapidly when burning. The heating value of osmon greatly exceeds that of wood and is about equal to that of lignite. The system can also be used for making osmon coke from the peat residues after gas-making.

Osmon is a very cheap fuel, and its manufacture is especially to be recommended for countries with natural water-power for producing electricity.

The latest use peat has found is in textile manufacture and as an unsurpassed isolating material, in which latter capacity nothing can compete with it but cork, which, however, is inferior, because it easily tears and

breaks, while peat consists of hollow, closely-packed cells filled with air and formed of "Suberin," which has an enormous chemical resistance, and its fiber being filled with air makes it a very bad conductor of heat and consequently an ideal isolator.

Peat also has the advantage of being proof against decay, the process of rotting having already been gone through, and its contents of humin acids greatly assist its capability of absorbing ammonia gases.

The promising industry for working up peat can use the raw material without any fermenting processes or apparatus such as are necessary for spinning wool or cotton, thus preserving as much as possible its natural qualities.

Being very warm, and yet porous, light-weight and perspiration-absorbing blankets for men and horses are made of it, also carpets and rugs, peat wadding, isolating ropes, paper, and cardboard.

Wood has long been used for paper-making in Germany, but the methods have been greatly improved, and by the Kellner-Türk patented process the finest threads of 30,000 meters length have been spun from sulfit or carbonate of soda (natron) cellulose. In the patent spinning works of Altdamm, near Stettin, cloth from such fir tree yarns is made. These yarns are sold under the name of "licella," and although inferior to cotton yarn, their wearing quality has been greatly improved by adding 1 to 2 per cent viscose to the pulp. Cloth made of licella yarns, on a cotton warp, 1.40 meters wide, costs 1 mark 25 pfennigs a meter, and a suit can be produced at a cost of 10 marks.

Another flourishing industry is the manufacture of artificial silk, which has already driven real silk out of certain lines in the manufacture of trimmings, because, although the strength of the silk thread seems inimitable, the gloss and chemical power of resistance of the artificial silk are greater.

In the technic of its manufacture the spinning process of the silkworm has been cleverly imitated. Just as the silkworm presses the fibrin, produced by its spinning glands, through two small openings of the mouth, so the cellulose pulp is forced out of two thin holes and then wound up on a cocoon.

In the chemical process of preparing the cellulose pulp, collodion is used, and it may here be mentioned that the modern explosives, also largely made with collodion consist no longer of cotton, as at first, but of wood cellulose. It has taken the inventor of artificial silk, Dr. Lehner, many years of experimenting before he could counteract the dangerous explosive qualities of collodion.

Dr. Lehner's original process has already been improved upon, and in Elberfeld the Vereinigte Glanzstoff Fabriken manufacture very high class artificial hair and straw for the manufacture of hats, etc., on the Pauly patent.

The very latest produce of wood cellulose is viscose, made in connection with the Continental Viskose Gesellschaft, in the new Kunstseide und Azetatwerke, in Sydowsaue, near Stettin, belonging to Prince Henckell-Donnersmark. By a chemical application of an ammonia solution or ammonia sulphate to viscose a plastic material called viscoid is made. Its utilization for the making of articles of common use, however, is still in the process of perfecting.

Another product of viscose, by an application of acetic acid, is the so-called "zellulosetetrazetat." At present its high price is its greatest drawback, its triumph being the thread which can be spun from it, and which is said to be almost equal to the fibroin of the silkworm.

The following is a statement of Dr. Max Müller, director of the factory in Sydowsaue, taken from an article of Prof. Otto N. Witt in Berlin on artificial silk, in which statement the prices for wood are compared with the value of products, namely:

1.	One cubic meter of wood weighing 400 to 500 kilogrammes costs in the forest.....	$0.71
2.	When sold as fuel to customers.....	1.42
3.	By boiling such log with soda, etc., about 150 kilogrammes of cellulose are produced, worth	7.14
4.	If working this quantity of cellulose up in paper, its value would be from $9.50 to	11.90
5.	If spun into cellulose yarn, as a substitute for jute or cotton, on the Kellner-Türk spinning process .....$11.90 to	23.80
6.	If made into an imitation of horsehair....	357.00
7.	If made into artificial silk	714.00
And finally,		
8.	If acetylized and made into an especially valuable kind of artificial silk, for certain specific uses	1,190.00

Finally, the distillation of wood should be mentioned. Its chief products are acetic acid, methylamine, aceton, and charcoal.

Dr. Bühler and Dr. Fischer, chemical specialists for distillation of wood, calculate, at a price of 5 to 6 marks for a cubic meter of beechwood, a profit of 15 to 20 per cent on an invested capital of 280,000 to 300,000 marks. The problem of drying the wood will be solved soon, as chemical science is busy with this subject. The most perfect factories for wood distillation exist in Germany, Austria, and Switzerland, as well as Sweden, while in America and Hungary only half-finished products are made.

The latest use of wood is very interesting, namely, the manufacture of sugar and spirit from wood. The chemical scientist, Dr. Roth, in Breslau, has so improved upon the already theoretically known methods that he is now experimenting on a large scale on an estate in Prussia, the patents of his system being owned by the Internationale Spiritis Industrie Gesellschaft in Berlin. His methods are based upon a carefully-gaged effect of a greatly diluted mineral acid upon cellulose, together with high pressure and heat, and afterward an energetic "oxidation" with the infusion of ozone. Dr. Roth produces by his method from 100 kilogrammes of sawdust 15 to 17 liters of 80 per cent spirit, and by using hydrogen peroxide the production is now said to be raised to 24 liters. By former experiments Simonson obtained 1.5 and Classen 3 liters of spirit. The cost of absolute alcohol by the Roth process is said to be 8 or 9, at highest 10 pfennigs, as compared to the price of 28 pfennigs for absolute alcohol obtained from potatoes or cereals. This invention is of the greatest importance if one considers the greatly increased demand for spirit for small

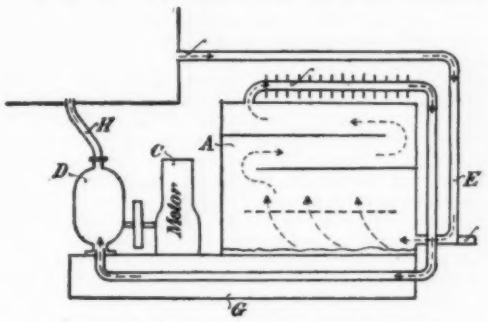


DIAGRAM OF CLAYTON APPARATUS.

motors. The profits are being calculated to amount to 103.25 per cent on the capital invested, or 47.04 per cent of the amount turned over.

If the new invention is not applied to the manufacture of spirit, but of sugar, the profits to be obtained are still more tempting; the manufacture of molasses, which is greatly in demand as a fodder for animals, especially for horses, showing a profit of 124 per cent on the capital invested or 45.75 per cent of the turnover.

The advantage of this latest invention is that the manufacture can be carried out in comparatively small works, such as for instance by the spirit factories on country estates.

Of the above-mentioned several new inventions, the following three seem the most important, namely, the manufacture of osmon from peat, the manufacture of molasses and spirit from wood, and the latest forms of utilizing beechwood.

THE PRESERVATION OF MAIZE DURING TRANSPORT BY THE CLAYTON PROCESS.

MAIZE, which is proved by the evidence of Mexican and Peruvian tombs to have been known before the discovery of America, is now of prime importance as food for man and beast. Corn meal is the chief ingredient of polenta, one of the staple foods of Italy, and of mamaliga, the national dish of Hungary and Bukowina. Green corn is eaten boiled, baked, or roasted in many parts of Europe as well as America. In some districts in Italy it is eaten raw, after being plunged into hot water. Corn meal is nearly as rich as wheat flour in albumen and starch, and costs only one-third or one-fourth as much. Maize is much used in South Africa as food and in brewing, and spirits and oil are obtained from it in various countries. It is also an excellent food for cattle.

Maize is cultivated extensively in the United States, Turkey, Austria-Hungary, Italy, France, Spain, Argentina, Portugal, Russia, and Egypt. In Argentina the production increased from 608,000 tons in 1894 to 3,000,000 tons in 1902, when nearly 1,200,000 tons were exported. In Germany, where very little maize is raised, owing to climatic conditions, the importation in 1897 amounted to nearly 1,300,000 tons.

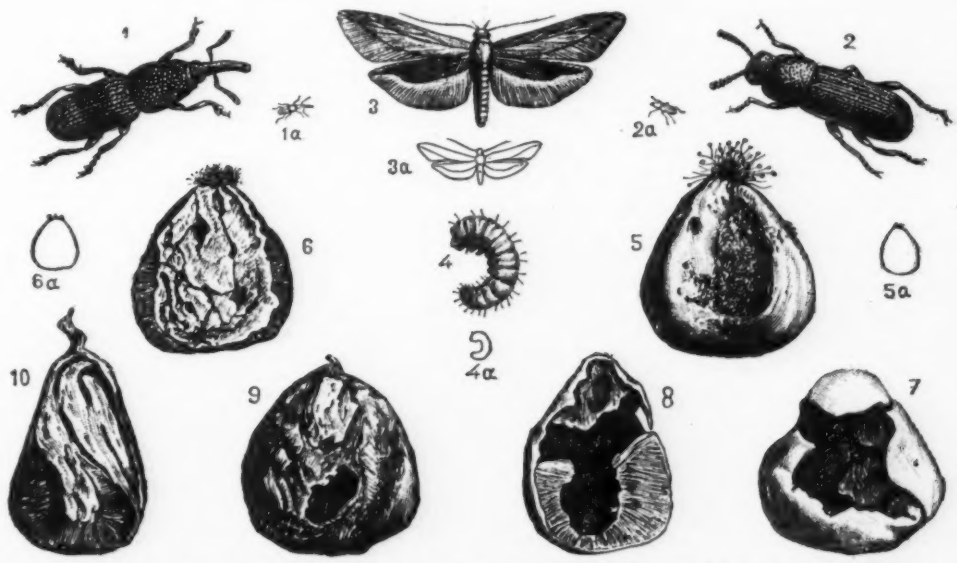
The use of maize as food, however, sometimes produces grave injury to health. The pellagra, or Milan rash, is, in the opinion of most investigators, caused chiefly by eating spoiled maize. This disease is characterized by serious disturbances of digestion, severe neuralgic pains and a peculiar inflammation, resembling erysipelas, of those parts of the skin that are exposed to the sun. The symptoms increase in severity until the seventh year, when death terminates sufferings which, in many cases, have produced madness or idiocy. This frightful disease occurs chiefly in Spain, southern France, Austria-Hungary, Rumania, and Italy. In Rumania there are now about 50,000 sufferers; in Italy, where two-thirds of the peasants live chiefly on maize, there are probably twice as many. Another malady apparently caused by maize is the pelade or Colombian disease, characterized by loss of hair and teeth and weakness of the extremities. This disease attacks both men and cattle.

Hence the question of the preservation of maize, especially during long ocean voyages, becomes of great importance. Many methods have been devised but all except one are too complicated to be employed aboard ship. The problem has recently been solved by Dr. A. Loir, as the result of his experiments on Argentine maize.

In Argentina the maize harvest extends from April to July. The maize intended for export is collected in immense elevators at the seaports. In respect to keeping qualities Argentine maize is divided into three grades. The first grade may be exported safely, as it usually stands the voyage well and it is therefore accepted by the insurance companies. Yet in 1902 the English companies alone paid nearly $1,400,000 for maize spoiled in transit. The second grade is not accepted by insurance companies. This fact increases the exporter's profit in the event of a lucky voyage, but very often more than half the cargo is spoiled in transit. The condition of the grain on arrival is betrayed by the escape of clouds of steam and foul odors when the compartments are opened. Sometimes the entire shipment is lost. In Genoa, in 1900, a cargo was thrown overboard by order of the local authorities, and the owner was ruined. The third grade of maize is never exported, for it is so wet that it spoils even before reaching Brazil.

Maize is attacked by various enemies. Among these are beetles of three species. *Loemophloeus pusillus*, found in many imported wares, is not very common in maize and its ravages are comparatively unimportant. *Tribolium ferrugineum* is a brown beetle about one-fifth of an inch long, related to the common meal beetle, *Tenebrio molitor*. *Calandra oryzae*, the rice weevil, usually destroys about five per cent of the cargo of a ship infested by it. Like its near relative, the black grain weevil (*C. granaria*) of Europe, it lays its eggs in the kernels, in which the larvæ feed, grow, and pass the pupal stage. The rice weevil, called *gorgojos* in Argentina, abounds in hot countries and has even invaded Europe, probably from Egypt.

Far more destructive than these beetles is the little moth *Sitotroga cerealella*, known in Argentina by the name of palomitas. Its larva operates in a manner resembling that of the white grain worm of Europe



1. Rice weevil (*Calandra oryzae*). 2. *Tribolium ferrugineum*. 3. Palomitas moth (*Sitotroga cerealella*). 4. Larva of Palomitas. 5. Moldy maize kernel. 6. Section of fermenting kernel. 7. Kernel injured by *Tribolium*. 8. Kernel injured by *Calandra*. 9. Fermenting kernel. 10. Section of kernel in first stage of fermentation. (Actual sizes shown by outline figures.)

which does not, like the black weevil, confine itself to the kernel in which it is hatched, but gnaws many kernels. The wounds thus made form excellent breeding places for bacteria and other fungi, and foci of decomposition, as Dr. Loir's observations abundantly prove.

The decomposition and fermentation of maize through the agency of molds and bacteria, favored by the heat of the ship's hold, are undoubtedly the most important sources of loss during transportation. The relation of the palomitas moth to these changes appears to be rather complex. As has been mentioned,

decomposition often commences in wounds made by the worms but it occurs also in previously sound kernels, usually in the depression that marks the position of the embryo, where it loosens the hard epidermis from the soft tissue beneath. Kernels thus affected are peculiarly liable to be selected by the moths as places of deposit for their eggs. It has long been known that fermentation and the palomitas usually occur together. The Argentine inspectors say that the moths are attracted by the odor of the fermenting grain and that their presence on a vessel is the surest indication of the bad condition of the cargo, while other authorities assert that decomposition affords equally certain evidence of the presence of the palomitas. Either cause of destruction may, however, operate alone.

Treatment with sulphur dioxide, that is to say, fumigation with sulphur, has long been recognized as the most effective means of preserving maize from decomposition, but the employment of this method on ships has, until recently, been out of the question, on account of the danger of fire. Dr. Loir, however, had the happy idea of using the Clayton apparatus and process which had already done excellent service in disinfection, extinguishing fires, and destroying vermin.

In preliminary experiments on a small scale he proved that maize exposed for two hours to Clayton gas was entirely freed of living bacteria and remained in good condition, even if wet, for two months, while similar wet maize, not so treated, spoiled in one month. The treatment also killed all insects without affecting the vitality of the maize, which sprouted vigorously. The first experiment on a large scale and in the conditions of commercial practice was made on the 6,000-ton steamer "Abergeldie," laden at Buenos Ayres with maize for Antwerp and London. Of the four compartments of the vessel only one, containing 2,000 tons of maize of all three grades, was connected with the Clayton apparatus in the engine room and fumigated four times during the 33 days' voyage. This compartment, in marked contrast to the others, was always entirely free from insects and foul odors and on arrival at Antwerp its contents were in perfect condition. There was not a trace of steam or of heating, which are certain indications of fermentation. One bag of maize, on which water had leaked, had sprouted as if to prove that it was uninjured by the treatment.

This experiment appears to have solved most satisfactorily the problem of the preservation of maize during transport and at the same time to have opened a new field of usefulness to the Clayton process.

The Clayton apparatus consists essentially of a gas generator, *A*; a motor, *C*; a Root blower, *D*, and a cooling device, *G*. In the generator or furnace, the bottom of which is covered with sand, sulphur is burned on a series of grates. From the top of the generator a pipe runs, through the cooling apparatus, to the bottom of the blower. The compartment to be fumigated is connected with the apparatus by the pipe *H* running from the top of the blower to a hole in the floor and the pipe, *E*, running from a hole in the wall to the bottom of the generator. By the operation of the blower the mixture of gases called Clayton gas, consisting of sulphur dioxide and other oxides and residual nitrogen, is drawn from the generator through the cooler and forced, at ordinary atmospheric temperature, into the compartment, the air of which is, at the same time, driven through the pipe *E* to the generator, where it is converted into Clayton gas. The pipe *E* may be put into communication with the external atmosphere by a valve, but this is opened only when the compartment contains inflammable gases, and for ventilation in the last stage of the process.

The apparatus is either installed permanently in the ship or brought alongside on the wharf, or on a lighter, as required. When fire is discovered in a compartment this, if not already in connection, is connected with the apparatus by hose, the sulphur in the generator is ignited by means of alcohol or kerosene, and the motor which drives the blower is started. The air of the compartment is thus drawn through the closed circuit of the apparatus until its free oxygen is so far exhausted by combination with sulphur that the fire is extinguished. Then the generator is cut out of the circuit and the heated gases continue to circulate through the compartment and the cooler until they are cooled to a safe temperature, when the valve is opened, the gases expelled and fresh air forced into the compartment.

It has been proved that burning petroleum, naphtha, turpentine, etc., can be extinguished almost instantly without danger of a second outbreak of fire, while with substances like cotton and hay, which retain much heat, the temperature must be reduced below 40 deg. C. (104 deg. F.) before the external air can be gradually admitted with safety. For the prevention of fire in very inflammable cargoes or such as are liable to spontaneous combustion the compartment is made airtight and Clayton gas is forced in until the air contains about 5 per cent of sulphur dioxide. (Clayton gas contains more than 15 per cent while 4 or 5 per cent is the most that can be obtained by burning sulphur in the compartment itself.)

For the preservation of maize, disinfection and destruction of rats and vermin, the process is the same as that above described. The suffocating gas drives rats and mice from their holes so that their bodies are easily accessible, which is not the case when they are killed by poison. The disinfecting action of the gas is increased by the heating of all the air of the compartment to 400 deg. or 500 deg. C. in the generator. The disinfection of a steamer of medium size occupies from 8 to 12 hours.

Experiments with various cargoes prove that the process does little or no injury, if the ship is thoroughly ventilated after fumigation. On perfectly dry wares Clayton gas has no effect. A few vegetable, but no mineral dyes are affected by it. Fresh meat, fresh fruit and some other articles of food absorb a little sulphur dioxide and polished metals are slightly dulled. Objects which are very sensitive to sulphur fumes can be protected by wrapping them lightly with porous paper. There are other effects which are transient and removed by airing.

The apparatus is suited to the disinfection of hospitals, barracks and other buildings, as well as ships.

GENESIS OF THE DIAMOND.*

By Dr. GEORGE F. KUNZ.

THE latest contribution to the much-debated question of the origin of the African diamonds is the paper by Mr. Gardner F. Williams, for many years the superintendent of the De Beers mines, on "The Genesis of the Diamond," presented before the Lake Superior meeting of the American Institute of Mining Engineers, in September, 1904.

In this valuable article Mr. Williams gives a very clear presentation of the entire field of both observation and speculation as presented by others, with his own comments and criticisms. With all his opportunities of long and wide experience, he has no definite theory to present; he regards the question of diamond genesis as still practically unsolved.

Between the igneous theory as advocated by Lewis in this country, Molengraaff in the Transvaal, and Stelzner in Germany, and the aqueous or mud-volcano theory of Crookes in England and of Meunier and Chaper in France, Mr. Williams inclines to the latter as "less assailable," though he by no means adopts it as satisfactory. He marshals, indeed, so strong a body of questions and difficulties against either view that his presentation is essentially negative. The blue ground is no doubt of volcanic origin, but it is in a breccia and not an altered outflow; it has been forced up from below, and the pipes or craters have been filled "by aqueous rather than igneous agencies, possibly by something in the nature of mud volcanoes." There is no indication of the material having ever formed elevations above the surface of the surrounding country. If such had formerly been the case, and the present condition had been brought about by erosion, diamonds and rock from the pipes would be found in the ravines and water courses in the vicinity; but they never are. No diamonds have been found in alluvium nearer than the Vaal River diggings, 20 miles distant; and the Vaal stones are entirely different in character from those of the pipes. This is one of Mr. Williams's strongest objections to the igneous theory—"There would have been overflows of the diamond-bearing rock which would have been found in the vicinity;" and no such deposits are known.

"It is much easier to reconcile existing conditions to the aqueous or mud-volcano theory (especially if the mud was accompanied by large quantities of gases which on nearing the surface escaped, while the mud receded) than to an igneous theory." Such action must have occurred many times in the pipes to account for the mixed-up character of the mass, the worn bowlder-like included fragments, and the slickensides and striations of the contact wall. This view is similar to those of Prof. Bonney and also of Sir William Crookes.†

As to the theory of the derivation of the diamonds from the carbon of carbonaceous shales pierced and shattered by the igneous magma in its ascent, which was advocated by Prof. H. Carvill Lewis with great apparent probability at an earlier stage of the workings, it has been sufficiently disproved by the fact that in the pipes near Pretoria, which yield diamonds freely, no carbonaceous shales occur.

Much stress is laid also upon the experiments of Herr W. Luzi, of Leipzig,‡ on the corrosion and evident partial solubility of diamond crystals in blue ground fused in a crucible at a temperature of 1,770 deg. Réaum. (equal to 2,212.5 deg. C., or 3,924.5 deg. F.). How is it possible, asks Mr. Williams, if such be the effect of a half hour of subjection to this comparatively moderate heat, that the diamonds in the actual blue ground could have retained so perfectly their form and brilliancy if they had been for long periods enveloped in the mass at the temperature required by an igneous outflow? An instance is cited of a diamond found at Kimberley, which contains included apophyllite, a mineral fusible before the ordinary blowpipe and containing 18 per cent of water. If this was formed simultaneously with the diamond crystal the temperature could not have been enormously high. The suggestion may be made, however, that possibly it may have formed later, through a crack in the diamond.

Much interest has been felt in Prof. Bonney's identification of eclogite bowlders from the Newlands mine, forty miles northwest of Kimberley, as perhaps the real source of the diamonds. Some were found in this rock, with quartz, etc., of the usual blue-ground type; and Prof. Bonney suggested that herein might be the real solution of the problem, that eclogite in a deeply buried terrane might be the true matrix of the diamonds and the source, by decomposition, of much of the blue-ground material.§ Some similar indications in New South Wales, apparently confirming such a view in the diamond region there, were noticed in the report of this Bureau for 1902. Mr. Williams, however, does not spare this last resting place of the seeker for the diamond matrix. He states that the eclogite is found in all the Kimberley mines and has been thrown out by tons as waste rock, and that no indication of a diamond has ever been found therein by himself, or by anyone that he has heard of. After Prof. Bonney's statement appeared he gathered twenty tons of it and had it crushed and examined with no result whatever. The eclogite theory has therefore but slender foundation.

The occasional rupture of diamonds after being taken out has been cited by Crookes and others as an evidence of their having been formed under great pressure, after the manner of the minute artificial diamonds of Moissan in molten iron. Jannetaz has argued that this result is due to compressed gas in the interior of the crystals.* Were this the case, says Mr. Williams, it would afford an additional argument against their having ever been exposed to a very high temperature in an igneous magma. In this connection the fact is stated positively that this rupture or explosion occurs only in diamonds that are pale brown or "smoky." It is liable to happen in these on their exposure to dry air at a slightly increased temperature. Broken diamonds are found in the pipes in great number, but the cause of their fracture is unknown.

Crookes has asserted that the ash of buried diamonds always shows iron as a chief constituent, and he looks upon this as confirmatory of the theory that they have been formed, like Moissan's, from molten iron. Mr. Williams joins issue here again and states that he has made exhaustive tests for iron, either metallic or oxydized, in many diamonds with powerful magnetic apparatus. The results were highly negative, even with diamonds that had a ferruginous aspect, and indicate clearly, if not the entire absence of iron, at least that its quantity is infinitesimal. The experiments of Moissan, Crookes, and others do prove the possibility of making microscopic diamonds in this way, but they throw very little light, in Mr. Williams's opinion, on the natural processes at Kimberley. He believes that all large diamonds have been formed like other crystals by long and slow accretion and not by any sudden solidification in a mass of fused iron. In further support of this view he cites some instances of diamond crystals formed around smaller ones within. One of these is a stone of 228 carats, found quite recently, which incloses a very small but perfectly formed red diamond crystal. Another is the specimen referred to before as including apophyllite. In this case the apophyllite formed a white coating upon a small crystal inclosed within a clear one, which latter was broken away in order to investigate the apparently white crystal within.

On the actual question of the formation of diamonds Mr. Williams takes again the same negative position that he did in his important volume published two years ago.† In concluding this paper he says:

"I regret that I am unable to propound a detailed theory as to the genesis of the diamond that could be supported by data less assailable and more conclusive than those given by others. I have suggested difficulties which have occurred to me in reference to various theories and which leave the subject still obscure."

Consistent Fats and Lubricants.—It may be of interest to collect in a brief space the principal facts relative to "consistent fats." The fats most generally employed for the preparation of this class are olein and colza oil separately, or sometimes together in equal parts. The average composition of a consistent fat is in general the following: Fatty matter, 16; spent lime, 4; mineral oil, 80.

The proportions may of course be varied according to the consistency desired. The quantity of water to add in saponification is quite important. It ought not to be either too much or too little. The proportion varies between 1.5 and 3.5 per cent. Consistent fat is, in general, colored either with aniline yellow, palm oil, chrome yellow, or again with a red color. Besides the consistent fats, of which the employments are now numerous, there is a series of other lubricants differing according to the nature or the purpose of the parts to be lubricated.

Adhesive grease for belting ought to be free from resin. The best quality is obtained by saponified wool grease, vegetable wax, or fish oil, with lime. Greases for metallic wires are obtained of good quality by a mixture of stearine, pitch, resin, tallow, mineral oil, and graphite. Grease for cocks consists of a mixture of caoutchouc, graphite, heavy mineral oil, tallow, and carnauba wax, dissolved together. Afterward talc may be added. By adding flaky graphite to a consistent fat an excellent lubricant is obtained for electrical machines.

A lubricant for hydraulic mechanism is prepared by mingling wool grease, paraffin, and mineral oil. For the lubrication of chains, a mixture of graphite and consistent fat is employed; while for hemp cables the consistent fat alone should be employed. A lubricant for rolling mills is prepared with stearine, pitch, and wool grease in equal parts, saponified by means of lime and mineral oil added. A lubricant for pivots and arbors is only consistent fat a little firmer than usual. For teeth gearing together, a mixture of consistent fat and graphite may be employed, or a mixture of tallow, oil, and graphite.—Translated from the Chemische Revue ueber die Fett- und Harz-Industrie.

* Abstract of a report published by the United States Geological Survey, Williams, G. F., The genesis of the diamond: Trans. Am. Inst. Min. Eng., Lake Superior meeting, September, 1904, vol. xxxv., 1905, pp. 440-455.

† See SCIENTIFIC AMERICAN SUPPLEMENTS 1551, 1552, 1553, 1554.

‡ Ber. d. deutsch. chem. Gesell., Berlin, 1902.

§ Proc. Royal Soc., London, vol. lxv., July 27, 1899; reviewed in Twenty-first Annual Report United States Geological Survey, Part 6 [Cont.], 1901, pp. 431-432.

* Bull. Soc. minérale France, vol. ii., 1879, p. 124.

† The Diamond Mines of South Africa, 1902.

ENGINEERING NOTES.

From the fact that the radiation from a hot body increases as the temperature rises, every attention should be given to the proper clothing of all parts of locomotive boilers and machinery that are generators and containers of high pressure, which would otherwise be exposed to the atmosphere. The rate at which the loss of heat extends will depend upon the difference in the temperature of the body emitting the heat and the surrounding atmosphere, and the condensation of steam inside of an unprotected steam pipe is dependent upon the temperature of the steam within, the temperature of the air without, and the velocity of the movement of that air. The metal composing the cylinders of steam engines is such a good conductor of heat that it responds instantly to the changes of temperature and a great many efforts have been made to keep the cylinders sufficiently hot to prevent the wasteful effects of what are known as initial condensation and re-evaporation at the beginning of the return stroke.

There are other things than fuel economy to be considered in deciding whether a novelty or a new design is worth its cost, observes Engineering Record in a recent issue. It matters little how much economy of fuel a device will secure if it is wanting in durability, for the annoyance caused by continual repair and disorder is sure to end in throwing the device out of use, and then there is realization of the fact that the money invested in it was practically thrown away. Closely allied to the subject of durability is that of maintenance. A device may have the requisite durability provided the person who has the care of it makes special efforts to watch it and keep it in order; but if not guarded by this vigilance it will soon deteriorate and become disabled. If durability is attained by what may be termed continual maintenance, it is not the kind of durability which is desired in an ideal steam plant. No real durability exists unless it can be obtained by the application of an ordinary amount of care, such as common workmen can be depended upon to furnish. If a plant, or any part of it, is not absolutely durable, there is a feeling of insecurity about it which offsets the combined advantages in every other line.

A large casting aggregating 84 tons, required as a mold for a heavy gun, was recently carried out at the Brightside Foundry in Sheffield, England. The mold was flanked by two furnaces containing 40 tons and 30 tons of molten metal respectively, while another furnace of 30 tons was brought from another part of the foundry some distance away. The third cupola on its carriage was brought along a railroad to the edge of the mold by two traveling cranes. The mold was crowned with a huge circular weight to keep it in position. Ten hours was occupied in the heating of the metal. When the preparations for the run were completed, two troughs of metal were directed into the mold from the adjacent furnaces, and simultaneously the third cupola was inverted. The run occupied ten minutes, and the casting was made without the slightest mishap, every care being taken to prevent "shelling" of the mold or "sparking." Cooling required 13 days, and then the casting was removed to the ordnance works for its 75-ton steel bath by the aid of three traction engines.

Among the numerous systems of gas-engines designed for the utilization of the waste gases of blast-furnaces and producer-gas may be mentioned the remarkable two-cycle engines designed by Mr. von Oechelhäuser. This system was one of the first to be applied to high-power engines. It was put into practice in the early part of 1898 in the shape of a 600-horse-power engine, and on that occasion disclosed its excellent qualities which have continued throughout a period of seven years' work. The main feature of the system consists in the employment of two trunk pistons working in a single cylinder, and thus reminds us of the device already applied for a certain number of years by Robson and made by Scott Brothers of Halifax (England). This engine was of the Otto type with distribution by valves, while the Von Oechelhäuser engine is of the two-cycle type, and the distribution is effected without the intervention of valves applied to the cylinder. This feature is the more interesting since, in large engines especially, the valves constitute delicate organs of difficult upkeep, having regard to the high temperatures to which they are subject in the explosion chambers. The front piston is attached by a connecting-rod to the center crank of a triple crank-shaft and works by thrust, at the time of the working explosion, while the back piston is attached by a system of swing-bar and counter-rods to the side cranks and works by pulling at the time of the explosion. The first advantage of the arrangement is the attainment of perfect balancing of the working parts, and particularly of the crank-shaft, with regard to which the driving efforts neutralize the reactions at the bearings. Again, the explosion chamber is formed by the cylinder itself and the ends of the pistons when the latter approach each other at the time of the ignition of the gaseous mixture. This explosion chamber thus forms a chamber presenting the minimum of surface cooled by water circulation and free from passages and recesses which on the ignition of the explosive mixture impede the movement of the pistons. These devices should have a manifest influence on the thermal output of the Von Oechelhäuser engine. The distribution is secured by the pistons themselves forming slide-valves, which uncover and in their movement again cover the ports provided in the cylinder for the admission of air and gas and the discharge of the products of combustion.

SCIENCE NOTES.

The time-scale in the transmutation of species of animals is furnished by the geological record, although it is not possible to translate that record into years. The time needed for a change of type in atoms or molecules may be measured by millionths of a second, while in the history of stars continuous changes may occupy millions of years. Notwithstanding this gigantic contrast in speed, yet the process involved seems to be essentially the same.

It would be extremely well if further attention could be directed to the matter of parthenogenesis in the higher plants. Except in the case of Nathanson's studies upon Marsilia, little has been done to indicate the conditions which may induce or which may tend to induce this process. In recent years, artificial fertilization, or stimulus to a certain growth of the egg in the lower animals, has been effected by chemical agents, by changes in the density of the solution, and by other means. This work has demanded world-wide attention from animal physiologists. It has been too much neglected from a botanical point of view, although the difficulties involved in similar studies with plants would be, for the most part, immeasurably greater. Yet it is certainly possible to prosecute such studies along the lines indicated.

There are centers of action which seem to have an eternal existence, changing only in the place that they occupy. These are the atoms. They keep together in some way and form the molecule; how, it is pretty hard to say. The planetary constellation, with ordinary attraction and centrifugal force in equilibrium, is excluded by the consideration that at the absolute zero there is no movement at all. The repulsive force that we want might be of electrical nature; and so we come to our combination of material and electrical atoms. There is indeed something fascinating here, and when we admit for carbon that it may unite to four equally charged electrical atoms and hold them by a force of the nature of elasticity, we have at once a possible equilibrium and the tetrahedral grouping. The only difficulty is that an uncharged atom of carbon, coming into contact with the ions just described, would take away half the electric charge, and so the valency of any element might be reduced to unity.

Not long ago three recent graduates were asked, each one from a different and entirely reputable school, why nitric acid is used to dissolve steel when one is going to determine the phosphorus? Why not use some other acid just as well? Two of the three replied that they supposed that nitric acid was a good solvent for steel, and they knew of no reason why any other acid that would dissolve the steel would not do as well. The third answered that in order to take the next step in the process it was essential that the phosphorus should exist as orthophosphoric acid, and that nitric acid being an oxidizing agent would bring the phosphorus to that condition. Now each of these three recent graduates knew how to determine phosphorus in steel, and, as a matter of fact, each of them had done it in an entirely acceptable manner and under check for six months or more. All three of them were familiar with the method and with the manipulation. But as we look at it only one of them had been properly taught. He not only knew the method and the manipulation, but he also knew the reasons why and the principles underlying the method. An assistant put the matter very forcibly. He said: "The chemist who knows methods and manipulation gets along swimmingly as long as everything goes well, and perhaps turns out more work in a day than a thinking chemist who understands the reason why for every step in his analysis; but let a difficulty arise and your method chemist is absolutely lost."

Exploration of the Upper Atmosphere by Means of Balloons.—In consequence of the experiments made at Monaco and in the region of the trade winds, for the exploration of the upper atmosphere by the Prince of Monaco, he was requested by Prof. Hergesell, of Strasburg, to apply to his researches the balloon methods, which have been employed with so much success on land. In compliance he conducted a series of experiments in the Mediterranean in April last, and on the ocean in the months of July and August; and recounts the results in a communication to the Académie des Sciences. Two India-rubber balloons, unequally inflated, bore the registering instrument and a float. At the height fixed in advance with sufficient approximation one of the balloons burst, and the apparatus in it fell to the surface of the sea. The second balloon, carrying the registering instrument, kept its position at a height of about fifty meters, and served as a guide to the vessel, which had followed the balloons. When the ascension at a fixed height is desired, the balloon is rendered free automatically by means of ungearing apparatus connected with an electro-magnet, worked by a dry battery, of which the circuit is closed by a barometer at the time indicated. Thus the height, temperature, and hygrometric state of the atmosphere were determined. But these data are not sufficient to make known the state of the atmosphere completely. To study the direction and velocity of the aerial currents the vessel followed as exactly as possible the direction taken by the balloons, while two observers on board made at fixed intervals determinations of the azimuth and other phenomena. The route and speed of the vessel being known, a simple geometrical construction allowed of tracing the horizontal projection of the trajectory followed by the balloons, a projection which determines for each instant the direction and velocity of the aerial currents. The maximum height attained was 14,000 meters above the Atlantic.

ELECTRICAL NOTES.

The British Admiralty intend to test wireless telegraphic communication between battleships in the forthcoming maneuvers. The tests are to be carried out upon an unprecedented scale, the whole of the various squadrons throughout the world operating simultaneously. Elaborate experiments are to be carried out to ascertain the ability of British vessels, with their existing apparatus, to intercept wireless signals transmitted between opposing vessels, and to what extent their apparatus can be adapted when their signals are being intercepted. In the preliminary operations one fleet will start from the coast of Spain and the other from the West African coast. Each will operate in divisions at about forty miles apart.

The electric furnace owes its place in the scientific and industrial world to certain characteristics which it possesses and to the advantages which it offers over other means of generating heat, the principal one being the high degree of temperature which is made available. An interesting comparison might be worked out showing that civilization progresses in a rate proportional to the utilization of heating energy in its highest degree of concentration. Each additional degree of temperature which can be produced and kept under control shows itself capable of new and useful purposes, and the electric furnace has added such an extension to the range of available temperatures, that it has almost doubled that previously available.

An advantage of electric traction, which will accrue to the general public, is the tremendous increase in the value of property in the neighborhood of a railroad. At the present time, no matter what the demand for property, that in the neighborhood of a railroad is handicapped for either residential or manufacturing purposes by the smoke and dirt. This will be entirely done away with, and in a city of any considerable size the property adjoining the railroad will increase in value by millions of dollars. Unfortunately for immediate development, this increase in property value affects the railroad only indirectly, and can hardly be considered one of the primary inducements for changing over to electric traction. These are some of the points where the public will be benefited, but the railroads are not of a philanthropic nature and it is the gains to themselves which will advance development.

In spite of all the striking advances which have been made in the field of X-ray therapeutics Dr. H. L. Jones, a well-known English physician, is by no means of the opinion that the older field of work with the so-called galvanic and faradic currents is exhausted. For example, the subject of electrolysis has lately come into prominence afresh, not for the destructive actions which it exercises in its application to nævus, moles, etc., but as a means of introducing drugs into the system and also, perhaps, for the withdrawal of injurious chemical bodies from the system. This use of electrolysis is not entirely novel; something may be found upon the subject in most of the older text-books of medical electricity, but of late a better comprehension of the physical laws of electrolysis is leading to new medical applications which promise to be useful.

The underground telegraph cable between London and Glasgow has now been completed. The distance between the two points is 400 miles, and the undertaking has cost $2,800,000, or $7,000 per mile. By the completion of this scheme the possibility of Scotland's isolation from London is rendered very remote. Hitherto communication between the two points has been frequently interrupted as the results of storms and blizzards, since the overhead sections in the Midland counties pass over bleak and exposed positions, and were thus easily susceptible to the slightest climatic and weather disturbances. The first section of this scheme was laid down five years ago as an experiment as far as Birmingham, and proved so efficient and reliable that extensions in all directions were carried out. Even when abnormally heavy working was thrown upon the cable by the overhead system breaking down, it proved more than equal to the strain. Though the initial cost is heavy, the expense of maintenance is so low that the difference in the outlay between the two systems has been more than compensated for. It is proposed to supplant gradually all the present trunk overhead lines to various parts of the country by underground cables, so that interruption may be reduced to a minimum.

If we consider the actual apparatus by means of which commercial telegraphy is effected, perhaps the most surprising fact that strikes the observer is the predominance of the use of the ordinary Morse code and Morse apparatus throughout the world. At first it seems surprising that, notwithstanding the innumerable inventions of printing, writing, and drawing telegraphs, the original system—of course, much improved—still holds the field generally, notwithstanding the partial use of the Hughes and Baudet printing systems on the continent of Europe. On consideration, however, it will no doubt be seen that, in comparing Morse with other systems that at first would appear to be superior, its simplicity, its relative freedom from trouble, electrical or mechanical, the ease with which its alphabet is learned and a skilled telegraphist is trained, and its adaptability to high-speed or multiplex working, all help to maintain it in the forefront, and undoubtedly will for a long time prevent, or delay, its general replacement by other types of instrument where the speed of working that is necessary is not greater than can be achieved by an operator manipulating a key. Where high-speed auto-

matic Morse apparatus, however, is in use, the want of a means of automatic transcription, which would save the labor and delay of manual transcription, has long been felt, and extremely promising systems have been devised whereby the problem has been solved in two different ways.

TRADE NOTES AND FORMULÆ.

Waterproof Paper.—A transparent water-proof paper having the appearance of parchment may be prepared by immersing silk paper in an aqueous solution of gum-lac and borax. After drying in the open air, pass over it a hot iron.—Corps Gras.

Bronzing of Objects with the Aid of Fire.—Make a homogeneous mixture of 5 parts of powdered red lead, 2 parts of graphite, and 5 parts of alcohol. With this cover the objects to be bronzed; dry for about an hour; then hold them over a charcoal fire, turning them in all directions. After cooling brush, and burnish if there is occasion. If a darker bronze is desired, add a little more graphite.—Corps Gras.

Waterproofing Coating for Cardboard.—Cardboard treated with the following preparation can be exposed to moisture: Melt together equal parts of good pitch and gutta percha; add to 9 parts of this mixture 3 parts of boiled linseed oil and 1½ parts of litharge. Heat and stir until the mixture is complete. Clarify, if necessary, with a little benzine, after heating the preparation.—Chimica Industriale.

Indelible Blue Ink.—This ink is said to resist not only water and oil, but alcohol, oxalic acid, alkalies, and chlorides. It is prepared by means of 4 parts of shellac, 2 parts of borax, 2 parts gum arabic, and sufficient indigo to give the desired color. The whole is dissolved in 40 parts of pure water. Commence by putting the shellac and the borax in 36 parts only of the water in a closed repectacle and boiling until completely dissolved. Filter, and then dissolve the gum arabic in the remainder of the water. Mix the two solutions and heat for five minutes, stirring from time to time. Add the indigo after the liquid is cool. When the preparation has settled for a few hours, decant in order to separate the ink from the sediment.—Science Pratique.

Adhesive Liquid Lubricant for Belting.—The following composition has been recently proposed: Soap works olein, 60 per cent; vaseline, 15 per cent; castor oil, about 5 per cent; rosin oil, 20 per cent; mix the whole and heat for seven or eight minutes, stirring constantly. By reason of the presence of the olein, the boiled product is perfectly clear and free from impurities in suspension. An increase of the percentage of the vaseline will cause the precipitation of the other constituents, and the separation of the oleic acid, which will float on the surface. The fat thus obtained applied to belts impregnates the leather, and does not dry or thicken, the leather remaining pliable.—Les Corps Gras Industriels.

The Sulphuric Acid Industry in Europe.—The most commonly employed raw material in England is sulphur, while in Germany it is pyrites. For grinding the ore the MacDougall ovens are employed in preference to others, the Hereshoff ovens for chilling the air, and the Frasch ovens for chilling the water. In France the lead chamber process has been improved and is regarded as securing the maximum of yield per unit of volume. In Germany the contact process is in favor.

The purification of sulphuric acid with reference to the percentage in arsenic has been the object of numerous researches. It is of capital importance. Various cases of poisoning have occurred in the use of products, whose manufacture necessitated the employment of sulphuric acid, glucose for example. The contact process has given excellent results, especially for concentrated acids, where it is even more economical than the lead chamber process.

The production of sulphuric acid is the most important chemical industry. The following are the producing countries in the order of their output: England, 1,100,000 tons per annum; Germany, 880,000 tons; United States, 870,000; France, 500,000; Italy, 200,000; Austria, 200,000; Belgium, 164,000; Russia, 125,000; Japan, 50,000 tons. The production of other countries is insignificant.—Revue de Chimie Industrielle.

The Bleaching of Ivory, Leather, Bone, and Horn.—Tanned leather, as we know, contains a quantity of fat and tannin, which must be removed before bleaching can take place. According to Bornträger, in the Bayerisches Industrie und Gewerbe Blatt, the leather is first digested with benzine for an hour, at 40 deg. C. The liquid is poured off, and the benzine removed by warming in a water bath, and the leather is then treated with liquid sulphuric acid, eau de Javelle, or hydrogen peroxide together with ammonia, etc. In all cases excellent results are reached; the product is pinkish white, and suitable, after careful drying, for fine handwork, book covers, etc. Iron is present here as iron oleate or iron tannate, both of which are soluble in benzine.

In bleaching ivory, horn, and bone, "two birds can be killed with one stone" by the process of shaking hydrogen peroxide with ether or benzine, whereby a volatile hydrogen peroxide is formed, the peroxide passing over into the ether or benzine. Separation is brought about by means of a separating funnel, and this hydrogen peroxide, carrying about 50 volumes of oxygen, is used to treat the ivory, horn, or bone. Thus the fat is dissolved and the bleaching carried on simultaneously. This bleaching process is of course expensive, and only to be recommended on a large scale and for fine work. It is good, however, in any event.

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TABLE OF CONTENTS.

PAGE

I. AERONAUTICS.—Proposed Solution of the Problem of Flight.—By FRANZ PABISCH.—5 illustrations 25173

II. AUTOMOBILES.—Gasoline-motor-propelled Roller.—1 illustration 25172

III. BIOLOGY.—The Influence of Light on Plant Development 25172

IV. CIVIL ENGINEERING.—Armored Concrete.—V.—By Lieut. HENRY J. JONES.—6 illustrations 25169

V. COMMERCE.—Transportation Routes and Systems of the World 25173

VI. ELECTRICITY.—Contemporary Electrical Science 25171
Electrical Notes 25179
The De Forest Syntonic System of Wireless Telegraphy.—By A. FREDERICK COLLINS.—8 illustrations 25169

VII. ENGINEERING.—Comparison Between Torpedo Boat and Merchant Marine Engines.—By Dr. ALFRED GRADENWITZ.—1 illustration 25165
Engineering Notes 25179
Liquid Fuel for Naval and Marine Uses.—II.—By Rear-Admiral GEORGE MELVILLE 25168
New Uses of Peat and Forest Products in Germany.—By WILLIAM MAYNES 25178

VIII. GEOLOGY.—Genesis of the Diamond.—By Dr. GEORGE F. KUNZ 25178

IX. MEDICINE AND SANITATION.—Insects as Carriers of Disease 25174

X. MISCELLANEOUS.—Oyster Culture in Japan.—2 illustrations 25176
Science Notes 25179
The Aladdin Cooker.—By EDWARD ATKINSON.—1 illustration 25173
Trade Notes and Formulæ 25180

XI. TECHNOLOGY.—Preservation of Maine during Transport by the Clayton Process.—11 illustrations 25177

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